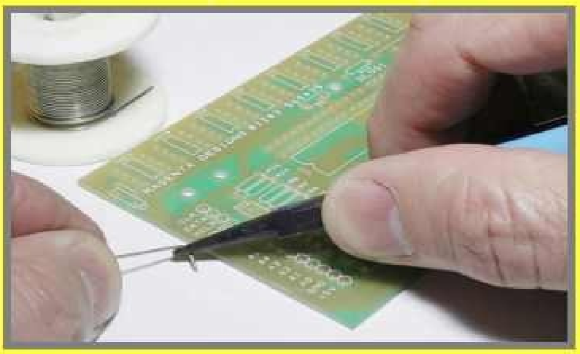
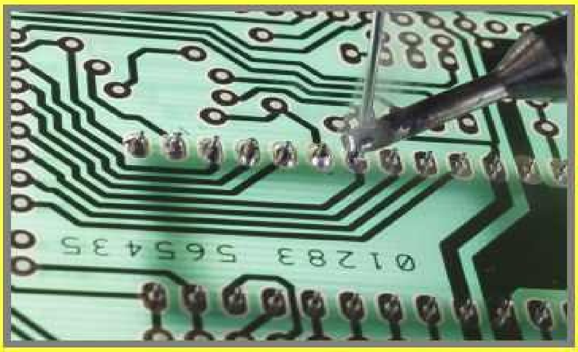
More than **80** photos

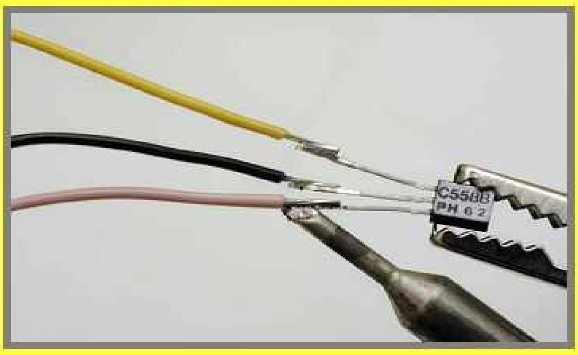
The Basic Soldering Guide

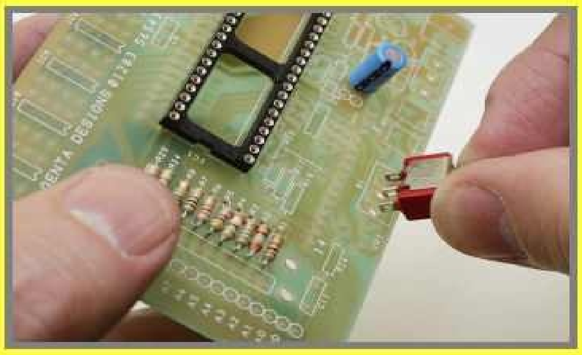
Learn to solder successfully!

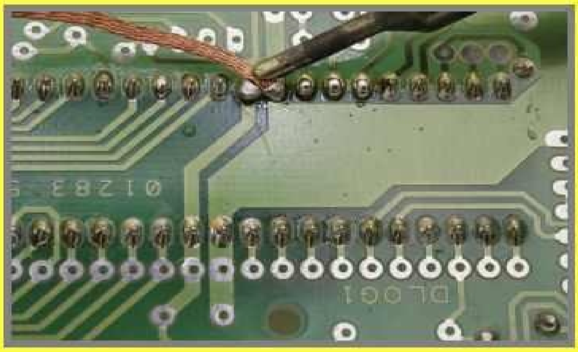
Alan Winstanley











In association with

ANTEX

ANTEX (Electronics) Limited

The Basic Soldering Guide
by Alan Winstanley
EPE Magazine Online Editor

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Where mentioned, the U.K. mains voltage supply is 230V a.c. and you should amend ratings for your local conditions.

Preface

In 1996 when the world wide web was still very young, I launched the first and most detailed website ever describing the practical skills of electronic soldering, and my **Basic Soldering Guide** quickly became the #1 web site of its kind in the Google search engine.

Thanks to its in-depth reference text and the unequalled high-quality close-up photography showing soldering step by step, many quickly learned the essential stages needed to make a solder joint successfully. Even novices who had never tried soldering before, gained the skills and confidence needed to acquire this skill.

My Basic Soldering Guide became a key *go-to* online guide for soldering, and I've enjoyed receiving encouraging feedback ever since from the likes of the US Air Force, US Marines, US Coastguard, Honeywell trainers, Atomic Energy authorities, Australian aeronautical suppliers, UK colleges and universities, trainees and many more around the world.

In association with Antex (Electronics) Ltd., the leading UK manufacturer of electronic soldering equipment, I'm delighted to bring you this updated Basic Soldering Guide containing over 80 all-new colour photographs, more background, more detailed information and lots more practical hints and tips.

I've revisited various areas of the guide and refreshed them, taking onboard readers' queries and nearly 17 years of online feedback, experiences and answering reader's questions. With the help of all-new photography, I'm sure you'll master the skills needed to solder electronics successfully using this updated guide.

I welcome feedback and comments, and readers can reach me via my website **www.alanwinstanley.com** or Email me at **alan@epemag.demon.co.uk**

Alan Winstanley

July 2013

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Introduction

The first and most important aspect of assembling any electronic project is that of *soldering,* which is a delicate and precise skill that can be mastered with experience. Sometimes called "soft soldering", there's no shortcut to acquiring the necessary expertise, and producing a consistently satisfactory solder joint takes a little practice. However, like riding a bicycle, soldering is an art which once learnt is never forgotten, and the purpose of this new and updated guide is to explain the techniques of soldering and desoldering for beginners, which I hope will set the hobbyist or trainee technician firmly on the road to successful electronic assembly or repairs in the future.

Soldering is the least "aggressive" way of joining non-ferrous metals together, and is used universally in electronics, air conditioning and refrigeration circuits, household plumbing and more besides – applications where the precise joining together of components at fairly moderate temperatures is needed. Further up the scale, **brazing** involves using higher temperatures to melt brazing rods onto larger metal parts, perhaps to repair a metal chair, lawnmower or to fabricate metal components or jewellery into intricate shapes. Lastly, **welding** is a very aggressive way of fabrication using welding rods or wire; steel girders, oil rigs and ships are all welded together, or robotic spot-welding is used for the mass production of, say, washing machines or car bodyshells using sheet steel to make strong rigid assemblies.

Due to the lower temperatures used and the need to make consistently good electrically conductive and mechanically sound joints with precision, soldering is used to connect components together when manufacturing electronic circuits. Small components would quickly be destroyed by brazing or welding, although tiny spot-welding joints do appear in electronics, perhaps to weld a metal tag onto a button battery.

This guide therefore deals with the soldering techniques used in electronics at hobbyist or trainee educational level. It explains what to look for before buying a soldering iron, describes ways of making various solder joints on circuit boards and other electronic components, and also how to *desolder* – removing solder in order to repair a circuit board or replace an electronic component.

You'll also find more details of other aspects of soldering, including an outline of typical solder types and fluxes. In short, everything you need to get started in electronics soldering is here, so let's get started!

First steps

The principle behind soldering sounds quite simple: the idea is to join components together to form an electrical connection, by using a mixture of lead and tin solder or alternatively “lead-free” solder (an alloy of tin and copper), which is melted onto the joint using a *soldering iron*. If you have never picked up a soldering iron before, then this guide will show you everything to help you start soldering with confidence. I also hope that the guidance will help those working in other areas — computer technicians or audio enthusiasts, for example, who may be faced with electronic repairs or modifications using a soldering iron for the first time.

If you’re an electronics hobbyist or trainee, before embarking on any form of ambitious electronic project, it is recommended that you practice your soldering technique on some *brand new* components using *clean* strip board (or protoboard) or a printed circuit board, and select a simple and straightforward constructional design as a starting point. Become acquainted and comfortable with your chosen soldering iron, which likely to become as familiar to you as a favourite pen. Learn how to balance it and handle it with precision. Try soldering an assortment of resistors, capacitors, diodes, transistors and integrated circuits with it, and then try your hand at *desoldering* – removing the solder again to make a repair or modification.

A really good place to start learning is by building a simple electronics kit, such as a Velleman kit that contains a good quality printed circuit board. You’ll learn some of the basic skills of successful soldering this way, and it’ll be a great confidence booster too.

Did you know? In the USA and elsewhere, the letter L in “solder” is silent and they say “soda” or “sodder” – but here in Britain we do pronounce the L and we say “sole-der”.

Soldering iron choices

Search any electronics catalogue or website and you'll see a bewildering array of soldering equipment on sale, including irons, controllers, work stations and desoldering equipment too. A large range of soldering irons is readily obtainable - which one is suitable for you depends on your budget and how serious your interest in electronics is, but there's something for every pocket distributed by a variety of retail, industrial and mail-order outlets.

The Antex range of soldering equipment has been very popular with industry, education and the electronics hobbyist for 60 years; I grew up with an Antex iron and a trusty 15W Antex iron was an everyday part of my hobby electronics all the way through the 1980's. An industrial user or a more dedicated hobbyist – with a bigger budget! – will be interested in a soldering station instead and again Antex offers a range of British-made products for industry or home use.

A very basic mains electric soldering iron can cost from under £5 (US$ 8), but I find that these very cheap irons, as sold on auction websites, are pretty crude and imprecise. They are best suited for simple electrical repairs and DIY rather than precision electronics or printed circuit boards discussed here. They tend to be bulky and uncomfortable for extended use, and they may not have suitable "bits" or tips of various sizes to suit different tasks.

^^ *This classic Antex XS25 "pencil style" 25W mains-powered soldering iron has exchangeable tips or "bits" and is great for general hobbyist or educational use. Stands are also available to store them safely in between use.*

A quality pencil-style electric soldering iron such as the Antex XS25 (photo) will be approximately £20 (US$18 tax free) - though it's possible to spend into three figures on a

soldering iron "station" if you're really serious about the subject! Don't be tempted to over-spend on an elaborate workstation though, unless you are really very serious about becoming involved in electronics. You will usually obtain perfectly satisfactory results using a fairly modest "pencil" iron model, and you can upgrade to something more sophisticated should your needs change in the future.

^^ *For enthusiasts or industry, this Antex 660TC soldering station has a separate mains-powered control unit and a matching low-voltage soldering iron rated at 24 Volts, 50 Watts so it's suited to a wider range of tasks than a lower powered one.*

When choosing your soldering iron, certain factors to bear in mind include:

Voltage: for the British market, "mains" electric irons run directly from the mains at 230V a.c. or will be set for other voltages (110V a.c.) depending on the country. However, **low voltage types** (e.g. 12V or 24V) usually form part of a "soldering station" for use with a matching controller made by the same manufacturer. Some low-voltage irons run off batteries (e.g. a car battery or Ni-cads) but these are uncommon.

Wattage: this is an extremely important factor to think about when choosing your iron. Typically, irons for general electronics work may have a power rating of between 15-25 watts or so, which is fine for most electronic assembly tasks, printed circuit boards and inter-wiring. It's important to note that a higher wattage does *not* mean that the iron runs hotter - it simply means that there is more power "in reserve" for coping with larger joints. The maximum electric iron wattage generally available is about 100W, which is OK for DIY electrical repairs but is far too high for general electronics or circuit board use.

A higher wattage iron offers you more flexibility for tackling a wider range of tasks. It has a better "recovery rate" which makes it more "unstoppable" when it comes to

heavier-duty work, because it won't be drained of its heat so quickly. So check the power ratings carefully, and anything between 15–40W is fine for general electronics soldering.

Temperature Control - the simplest and cheapest types don't have any form of temperature "regulation". Simply plug them into the mains and switch them on! Thermal regulation is "designed in" (by physics, not electronics!). Sometimes they are described as "thermally balanced" as they have some degree of temperature "matching" – in other words, they warm up as quickly as they lose heat during use, so in a primitive way they maintain roughly a constant temperature. This type of iron is perfectly acceptable for hobby or less demanding professional use. It's essential to use the manufacturer's specified tips (see later) to maintain proper temperature matching, otherwise the iron may not heat up enough – or it may overshoot in temperature.

These unregulated irons form an ideal general-purpose iron for most users, and they cope reasonably well with printed circuit board soldering and general interwiring. However, most of these "miniature" types of iron will be of little use when attempting to solder large joints (e.g. very large terminals or very thick copper wires) because the components being soldered will draw or "sink" heat away from the tip of the iron, cooling it down too much and preventing solder from flowing properly. That's when a higher wattage iron is needed.

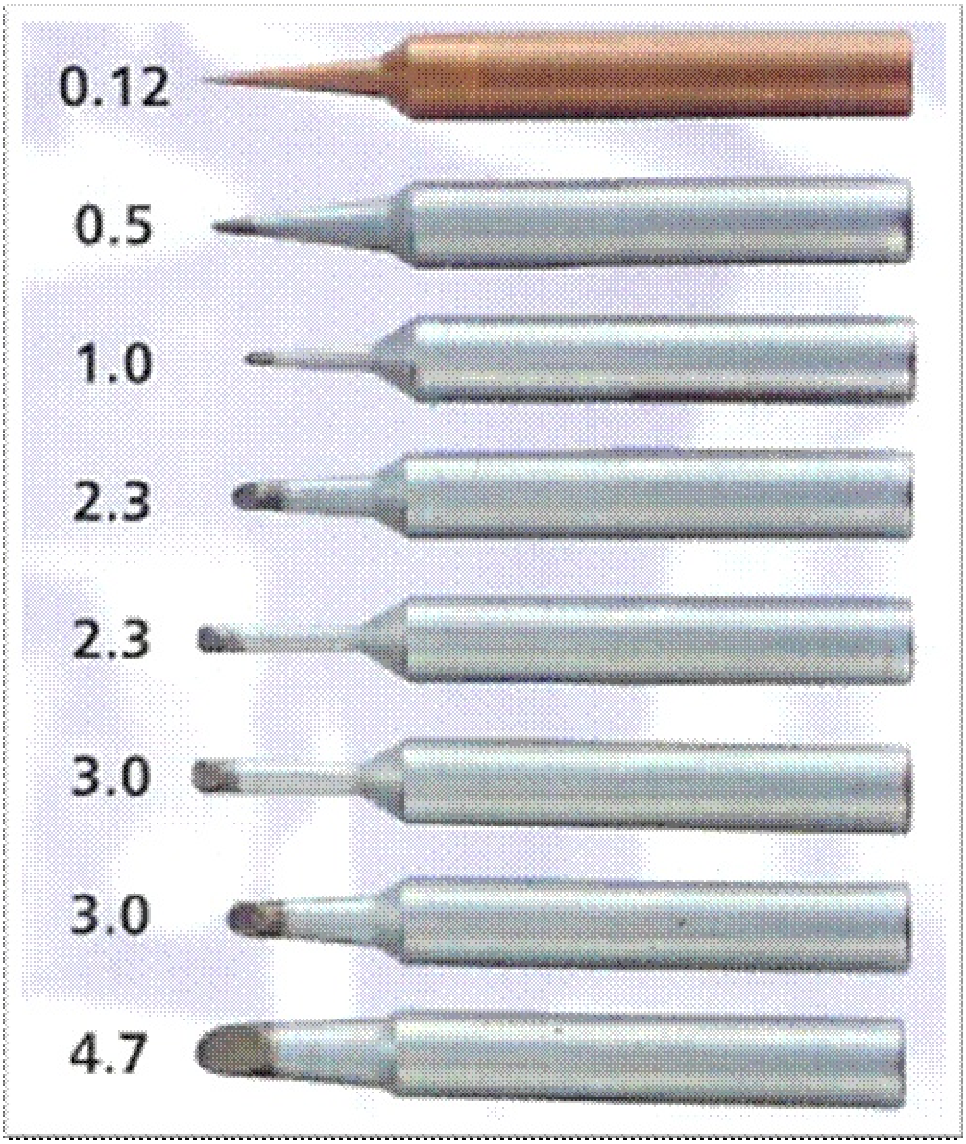
A proper **temperature-controlled iron** will be quite a lot more expensive - retailing at say £40 (US$ 60) or more - and will have some form of built-in thermostatic control, to ensure that the temperature of the "bit" (the tip of the iron) is maintained at a fixed level within reasonable limits. This is desirable during frequent use, since it helps to ensure that the temperature will be relatively stable regardless of the workload. Some irons have a bimetallic strip thermostat built into the handle which gives an audible "click" in use, and some may include an adjustable screwdriver control within the handle as well. Others may have electronic controls built in.

^^ *An Antex 660TC soldering station with matching iron and bench stand.*

More expensive still, **soldering stations** cost from £70 (US$ 115) upwards (the iron may be sold separately, so you can pick the type you prefer), and consist of a complete bench-top control unit into which a special *low-voltage* soldering iron is plugged. Some versions might have a built-in digital temperature readout, and a control knob to vary the setting. The temperature could be boosted for soldering larger joints, for example, or for using higher melting-point solders (e.g. lead-free or silver solder). These are designed for the discerning user, or for continuous production line or professional use. A thermocouple will be built into the tip or shaft, which monitors temperature.

The best soldering stations have irons which are well balanced, with comfort-grip handles which remain cool all day, and silicone-based cables which are burn proof. Antex produces a range of irons with silicone cables specially for education use, to help avoid accidents caused by careless use by students.

Anti-static protection: if you need to solder a lot of static-sensitive parts (e.g. CMOS chips or MOSFET transistors), more advanced and expensive soldering iron stations use static-dissipative materials in their construction to avoid static charges accumulating on the iron itself, which could otherwise damage or “zap” some semiconductors. Such irons are listed as “ESD safe” (electro-static discharge proof). The cheapest irons are not classed as ESD-safe but they still perform well enough in most hobby or educational applications provided you take the usual anti-static precautions when handling these components. The iron would need to be well earthed (grounded) in these circumstances, to carry away any static.



^^ *Just part of the range of spare tips or "bits" produced by Antex for their soldering irons. Use only tips intended for a particular iron, to avoid thermal matching problems.*

Tips or Bits: it's often useful to have a small selection of manufacturer's bits (soldering iron tips) available with different diameters or shapes, which can be changed depending on the type of work in hand. You will probably find that you become accustomed to, and work best with, one particular shape of tip for the majority of your work. Usually, tips are iron-coated or plated to preserve their life and to maintain good tip "hygiene". Be sure only to use tips that are specifically designed for your iron, otherwise thermal problems may arise. I show separately some typical tips, courtesy of Antex.

^^ *Useful accessories from Antex including solder, tips and tip cleaner, desoldering braid and a heatshunt.*

Spare parts: it's always reassuring to know that spares are available in the future if required, so if the element blows, you don't need to replace the entire iron. This is especially the case with expensive irons. Check some websites or mail-order catalogues to see whether spare parts are listed. One drawback is that you may need another soldering iron when exchanging a broken heating element!

^^ *Gascat 40 gas-powered soldering iron kit by Antex, with spare tips and cleaning sponge.*

Gas or electric? So far I've discussed electric soldering irons, but **gas-powered** soldering irons are sold which use butane propellant rather than mains electricity to operate. They have a flint lighter or (better still) a built-in piezo for ignition, and have a catalytic element which, once warmed up, continues to glow hot when gas passes over them. They tend to be big and bulky compared to electric pencil irons.

Field service engineers use gas-powered irons for working on repairs where there may be no power available, or where a joint is tricky to reach with a normal electric iron, so they are really for occasional "on the spot" use, rather than for mainstream construction or assembly work. I use one when I just need to do a quick repair and can't be bothered getting the electric soldering iron going!

Gas irons can have higher power equivalents than electric ones (eg 125 watts or more) but some gas-powered irons are nothing more than miniaturised blowtorches, which may or may not be useful for occasional heavier duty soldering. In the author's experience they can be difficult to use in confined areas. *Extreme care is needed at all times to ensure hot gas emitted from the iron's exhaust port doesn't damage nearby materials, plastics or wiring.* Gas irons can have useful accessories to convert them into e.g. a hot knife for sealing nylon rope, or a hot-air blower for use with heatshrink tubing. Almost every electronics constructor uses an electric-powered iron though.

A **solder gun** is a pistol-shaped iron, typically running at 100W or more, and is completely unsuitable for soldering modern electronic components: they're too hot, heavy and unwieldy for micro-electronics use, nor are they designed for that. Plumbing or DIY, maybe..!

^^ *A heat resistant soldering iron stand with cleaning sponge. (Antex)*

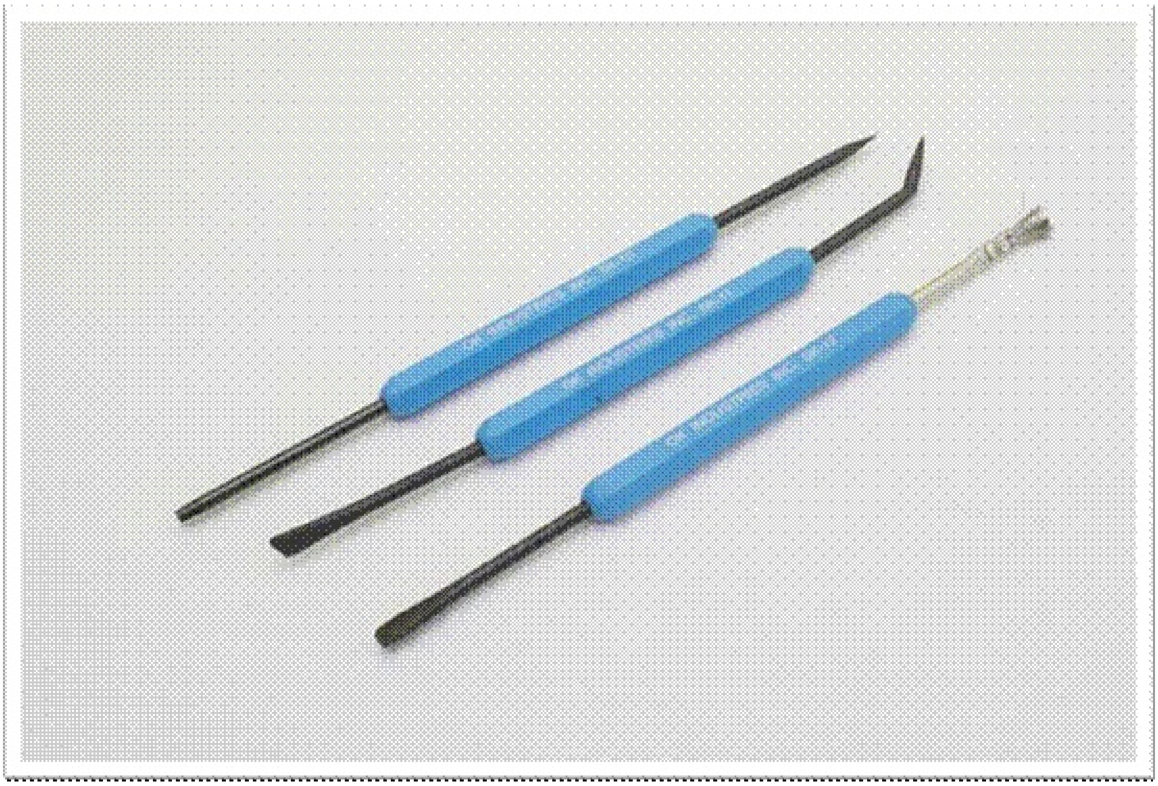
Soldering irons are best used along with a **heat-resistant bench stand**, where the hot iron can be safely stored in between use (photo). It is extremely important that a hot

soldering iron is safely “parked” ready for action, and a bench stand is really a necessity. Soldering stations usually have such a feature, otherwise a separate soldering iron stand is essential, ideally one that’s supplied with a tip-cleaning sponge. You can make your own cleaning sponges using *cellulose* sponge only.

^^ *A benchtop fume extractor fan for hobbyist use. A replaceable carbon filter helps remove particles and air is vented out the back.*

Other equipment worth considering includes the use of **fume extractors**, which are compulsory in the industrial workplace. Solder fumes and flux smoke are not known to be toxic but they can cause irritation. A basic fume extractor (photo) consists of a small bench-top fan which draw fumes and irritating smoke away from the operator’s face and filters out some of the smoke particles, before exhausting the air back out through the fan. The carbon-impregnated foam filters are replaceable. Such devices are quite effective and users soon find them indispensable, even though they can be a bit noisy at close range.

Professional fume extraction systems draw the smoke and fumes directly from the work area via a clip-on tube fitted to the soldering iron, then vent the fumes away through a large filter pump. It is definitely worth considering a small bench top unit for regular hobby or occasional professional use, as having decent ventilation can only be a good thing.



^^ *A soldering accessory toolkit by OK Industries, including probes, scrapers and wire brush*

A variety of specialist **hand tools** are available that assist with soldering, and a good supplier's catalogue will offer a range of small brushes, scrapers and cleaning tools in a handy kit, together with the usual types of wire cutters, pliers and so forth, which are necessary for handling components and tidying up as required. Some specialist service aids (aerosols etc.) are also described later.

Now let's look at how to use soldering irons properly, and later on we will describe the techniques for putting things right when a joint somehow goes wrong — and don't worry, even the experts get it wrong sometimes!

How to solder

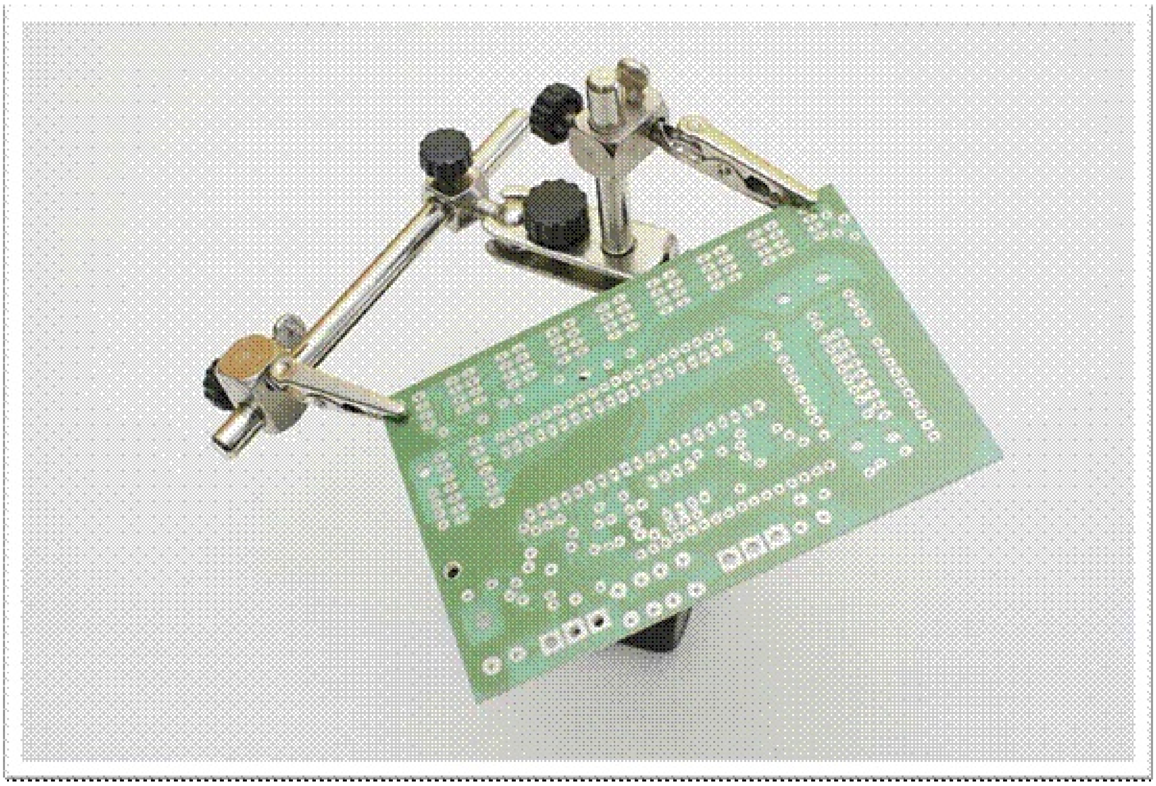
This guide will show you step by step how to solder successfully and plenty of photographs are provided to help explain the techniques needed.As you read through the guide I'll explain all the stages in more detail, but let's look at the basics first.

First of all, successful soldering requires that the items being soldered together are held with as little movement as possible. So it's best to *secure the work* as needed, so that your accuracy isn't affected should the workpiece move accidentally.

In the case of a printed circuit board, various holding frames are useful especially when densely populated boards are being soldered: the idea is to insert all the parts on one side (a process called "stuffing the board"), hold them in place with a suitable pad to prevent them falling out again, turn the board over and then snip off the wires with cutters before soldering the joints. The frame saves an awful lot of turning the board over and back again, especially with large boards: all the soldering can be performed in one pass.

^^ The ever-popular "Helping Hands" (left) helps support sundry parts, wires etc. during soldering.
A modeller's vice (right) holds parts firmly. A vacuum base fixes it onto smooth surfaces.

Only the more serious constructor will purchase a holding frame, and hobbyists can retain parts in place by improvising in a variety of ways – the ever popular "Helping Hands" stands cost a few pounds and is widely sold. They have adjustable crocodile clips to grip parts, and maybe a magnifying glass or soldering iron stand as well. The cast iron base provides stability. Other parts could be held firm in a modeller's small vice, for example.



^^ *"Helping Hands" uses crocodile clips to grip parts during soldering. Or just place parts flat on the bench.*

When soldering parts onto an ordinary circuit board, components' wires can simply be bent to the correct pitch (distance apart) to fit through the board, insert the part flush down against the board's surface, splay the wires a little so that the component grips the board under spring tension, and then solder it. This technique is universally used in manual **through-hole soldering,** which is explained in full later.

In the author's view - opinions vary – it's generally better to snip off the surplus wires leads first, to make the joint and neighbouring joints more accessible and also to reduce the mechanical shock transmitted to the p.c.b. copper foil. However, in the case of diodes and transistors the author tends to leave the snipping until after the joint has been made, since the excess wire will help to "sink" heat away from the heat-sensitive semiconductor junction.

A special clip-on heatsink is available which also helps stop excess heat from reaching temperature-sensitive semiconductors like these. I've always managed without one but beginners might find them reassuring. Integrated circuits can either be soldered directly into place if you are confident enough, or better, use a dual-in-line socket to prevent heat damage. The chip can then be swapped out at a later date if needed.

Parts which become hot in operation (e.g. some power resistors), should be raised above the board slightly to allow air to circulate. Some components, especially large electrolytic capacitors, may require a mounting clip to be screwed down to the board first, otherwise the part may eventually break off due to vibration. It's a good idea to bolt such components firmly into place before soldering their terminals, in order not to strain the soldered joints or the components when fasteners are tightened.

By securing the workpiece as much as possible to prevent movement, you have a

much higher chance of producing good-quality reliable solder joints.

Next steps

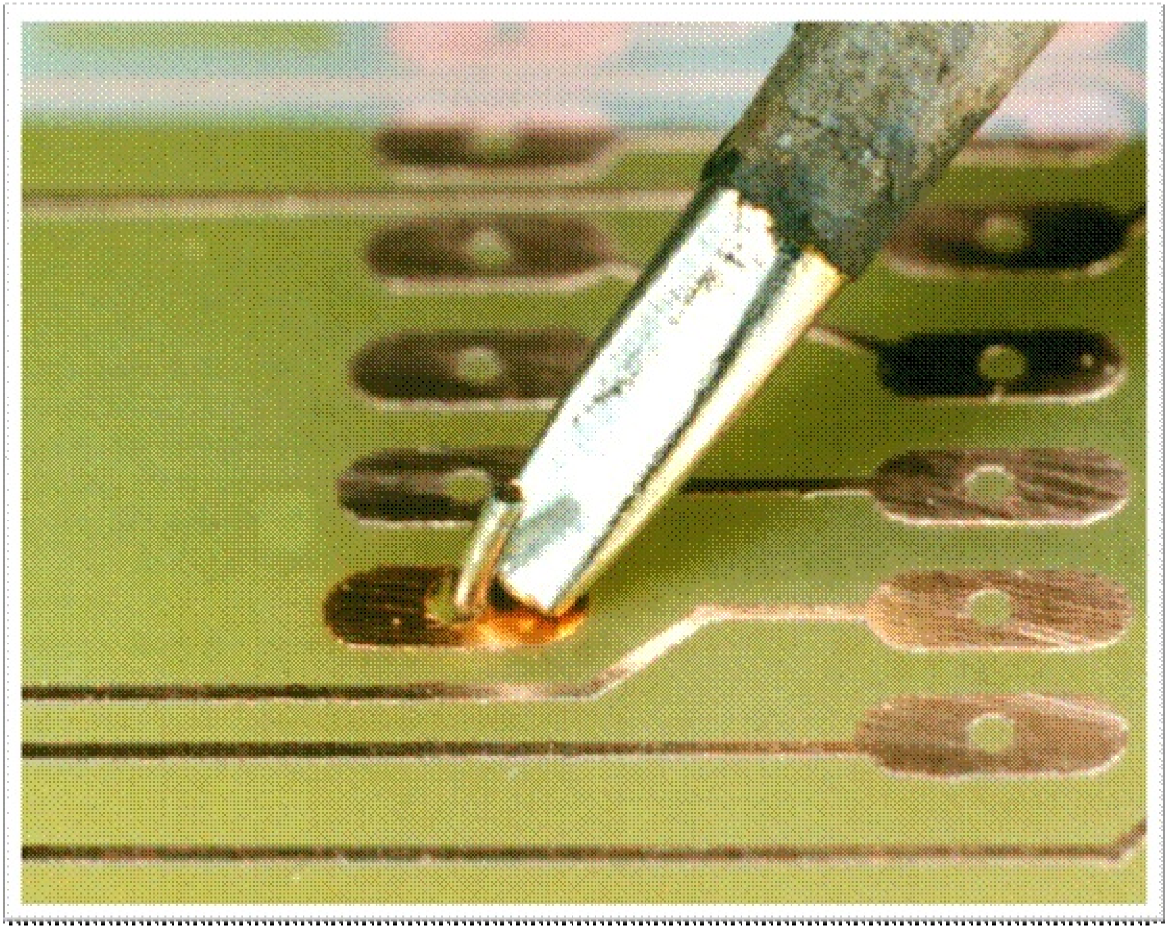
Let’s get to grips with actual soldering techniques in more detail. The soldering of electronics components utilises **lead/ tin** or **lead-free solder** and the process is compatible with many non-ferrous metals. You can solder copper, lead, brass, gold plate, silver, nickel, tin and tin plate, zinc and more besides but some metals such as nichrome, galvanised or stainless steel require a highly specialist “flux” (see later) to solder them and aren’t discussed here. Some materials such as beryllium, chromium, magnesium and titanium are non-solderable in any case, according to solder manufacturers Multicore.

In electronics we’re mainly concerned with soldering parts or wires onto printed circuit boards or terminals that are usually already “tinned” with solder or plated, ready for soldering with flux-cored solder. The key factors affecting the quality of a solder joint are:

- **Cleanliness** – dirt or impurities drastically hinder good solder coverage.
- **Temperature** – the right level to enable the solder to flow freely!
- **Time** – apply heat for just the right amount of time!
- **Adequate solder coverage** – enough to form a good joint without touching neighbouring areas.

A little effort spent now in soldering the perfect joint may save you — or somebody else —a considerable amount of time in troubleshooting a defective joint in the future. Let’s discuss the basic principles outlined above in more depth.

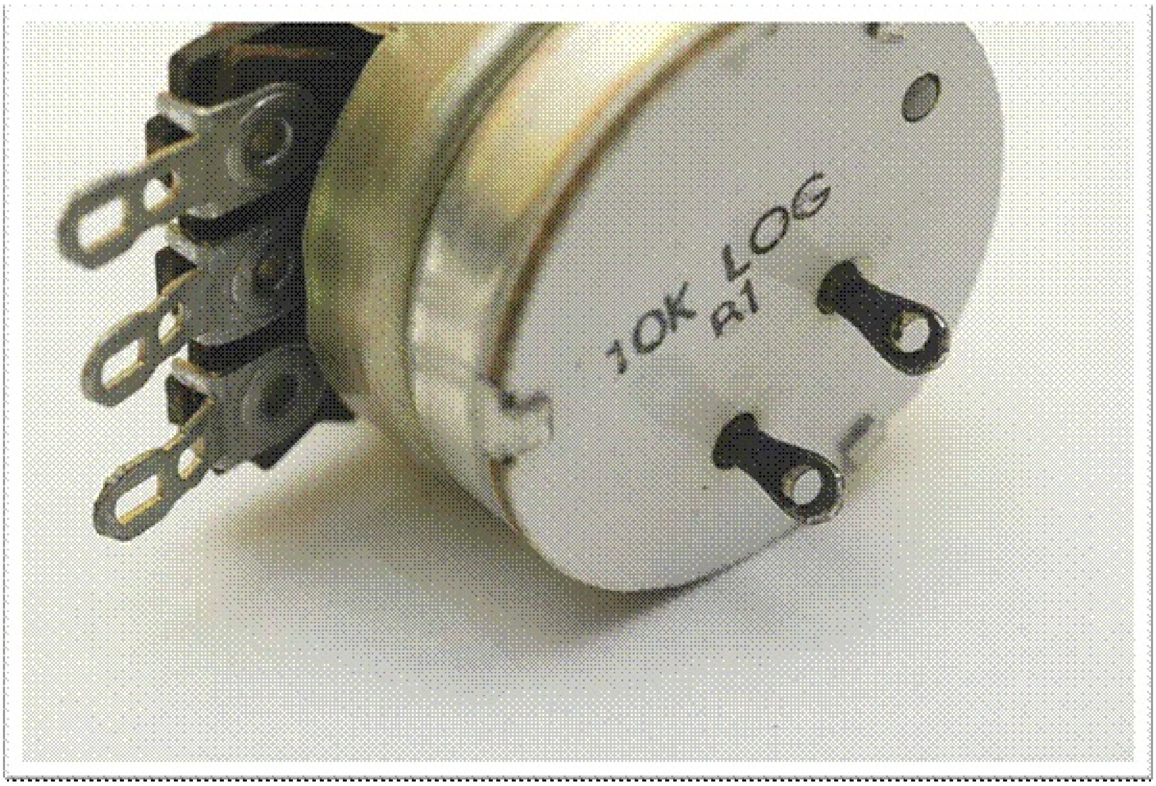
Cleanliness and "Tinning" the bit



^^ A clean and shiny soldering tip or "bit" is essential for each and every solder joint you make.

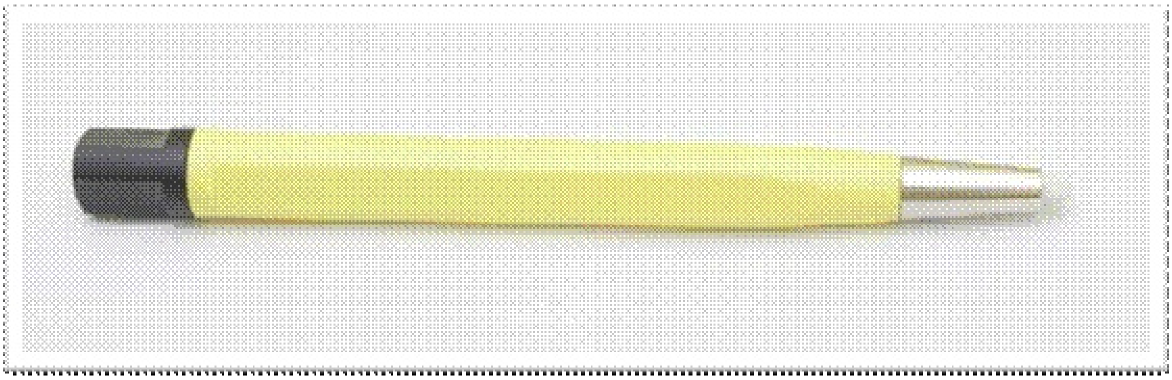
Firstly, and without exception, all parts - including the soldering iron's tip itself - must be clean and free from contamination. Fact is, solder just will not "take" to dirty parts! Old components or copper board can be impossible to solder because of oxidation that builds up on the surface of the leads. This repels the molten solder and will soon become evident because the solder will "bead" into shiny globules looking like mercury, going everywhere except where you need it. *Dirt and contamination are the enemies of a good quality soldered joint!*

When all the conditions are right for soldering, materials are said to be "wettable" and will accept molten solder, which should flow readily over their surfaces. Hence, it's **really necessary** to ensure that parts are free from grease, oxidation and other contaminants. Note that in any case, some incompatible materials or surface finishes just cannot be soldered using ordinary lead-free solder, no matter how hard you try – e.g. aluminium parts would require special aluminium solder and fluxes (see later) to be used.

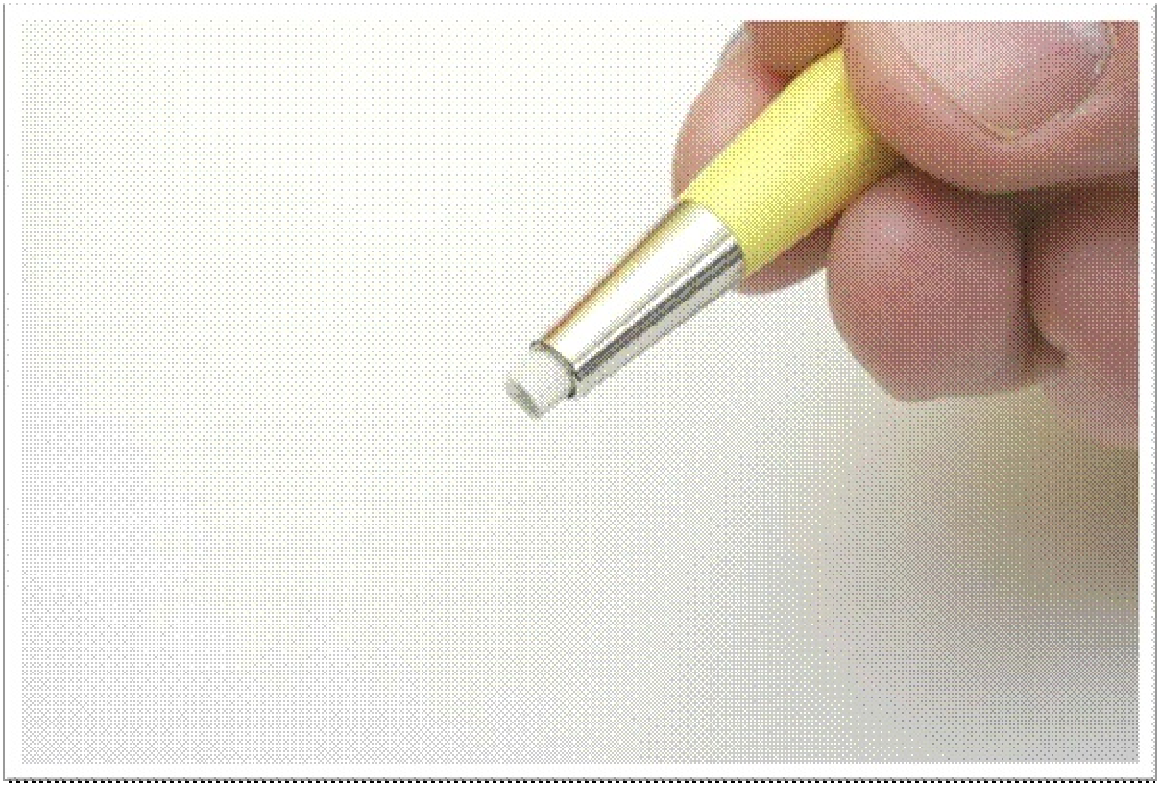


^^ The two tags on this switched potentiometer have blackened with age and oxidation. They must be cleaned before they can be soldered…

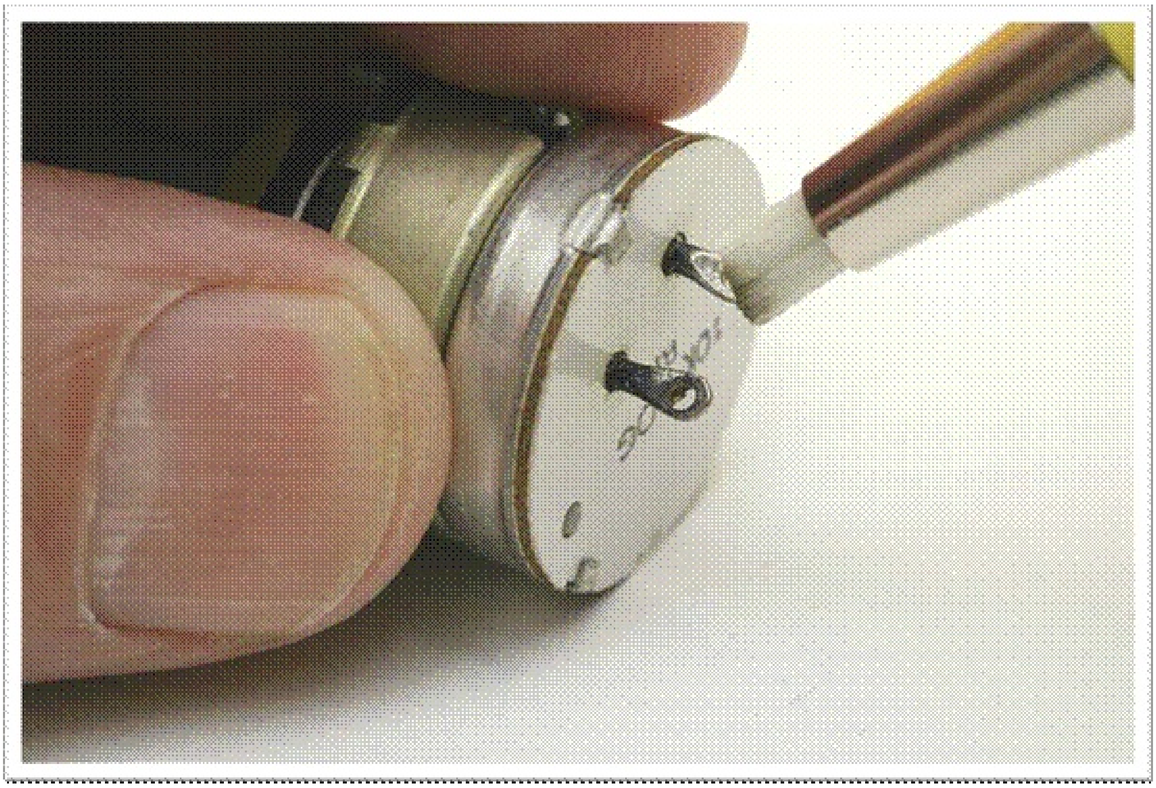
In the case of old components that have been stored a long time, where the leads have blackened and oxidised, use a small hand-held file or perhaps fine emery cloth to reveal fresh metal underneath. Stripboard and copper printed circuit board will generally oxidise after a few months, especially where it has tarnished due to fingerprints, so the copper strips could be cleaned using e.g. an abrasive rubber block made for the purpose. Also available is a fibre-glass filament brush (photo), which is used propelling-pencil-like to remove contamination. They're OK for general cleaning but best avoided on fine surfaces (e.g. gold plated switch contacts). These produce tiny particles which can irritate the skin, so avoid accidental contact with any debris.



^^ A glass-fibre filament brush like this is useful for cleaning oxidised parts.



^^ The glass-fibre brush works like a propelling pencil and produces irritating dust.



^^ Cleaning oxidised tags with a glass fibre brush to make them nice and shiny, ready for soldering

Afterwards, a wipe with a rag soaked in cleaning solvent will remove most grease marks and fingerprints. After preparing the surfaces, avoid touching any parts as far as possible.

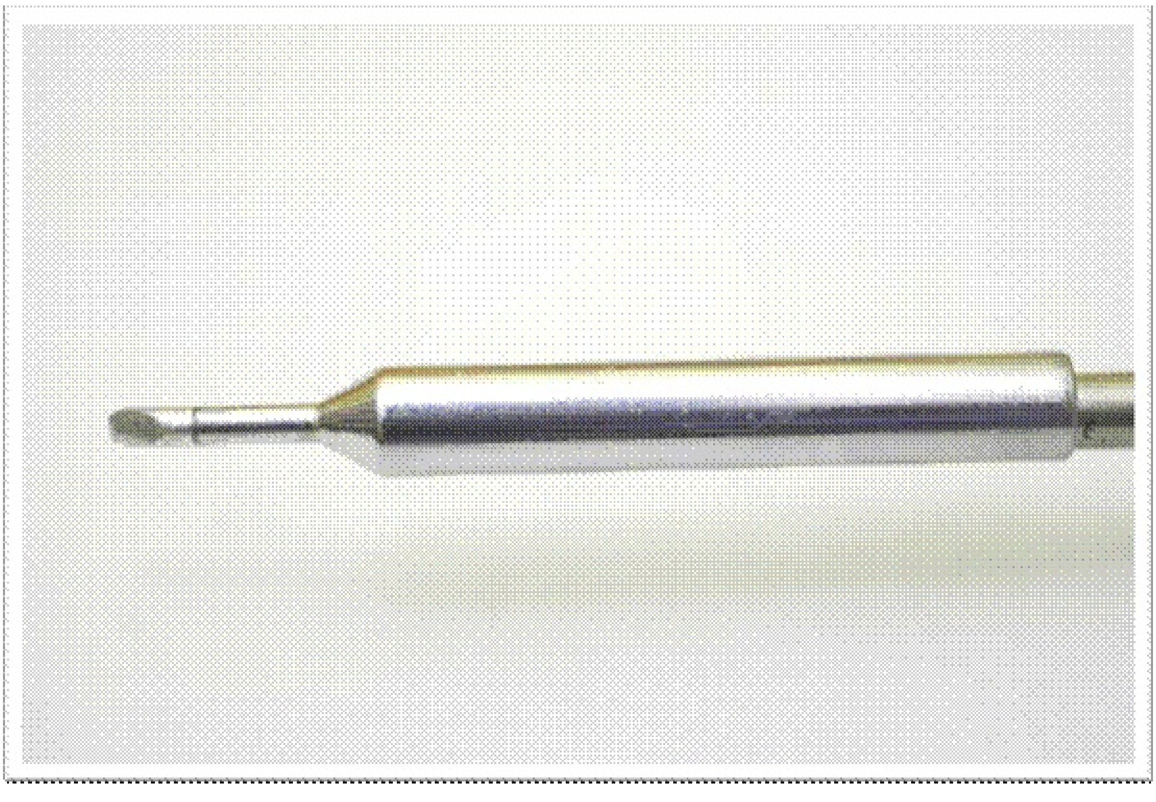
Another side effect of trying to solder contaminated or incompatible materials is the tendency to apply more heat and "force the solder to take". As the materials aren't

wettable the molten solder won’t flow where you want it to flow. This can do more harm than good, because it may be impossible to burn off any contaminants anyway, and the component or the printed circuit board may be overheated and damaged in the process. Semiconductors may be harmed by applying excessive heat for more than a few seconds, and extreme heat applied to printed circuit board tracks can cause irreparable damage, because the tracks will be lifted away from the substrate especially on a delicate or badly designed board. You can avoid trouble by ensuring the surfaces to be soldered are clean and wettable to begin with.

Getting Ready

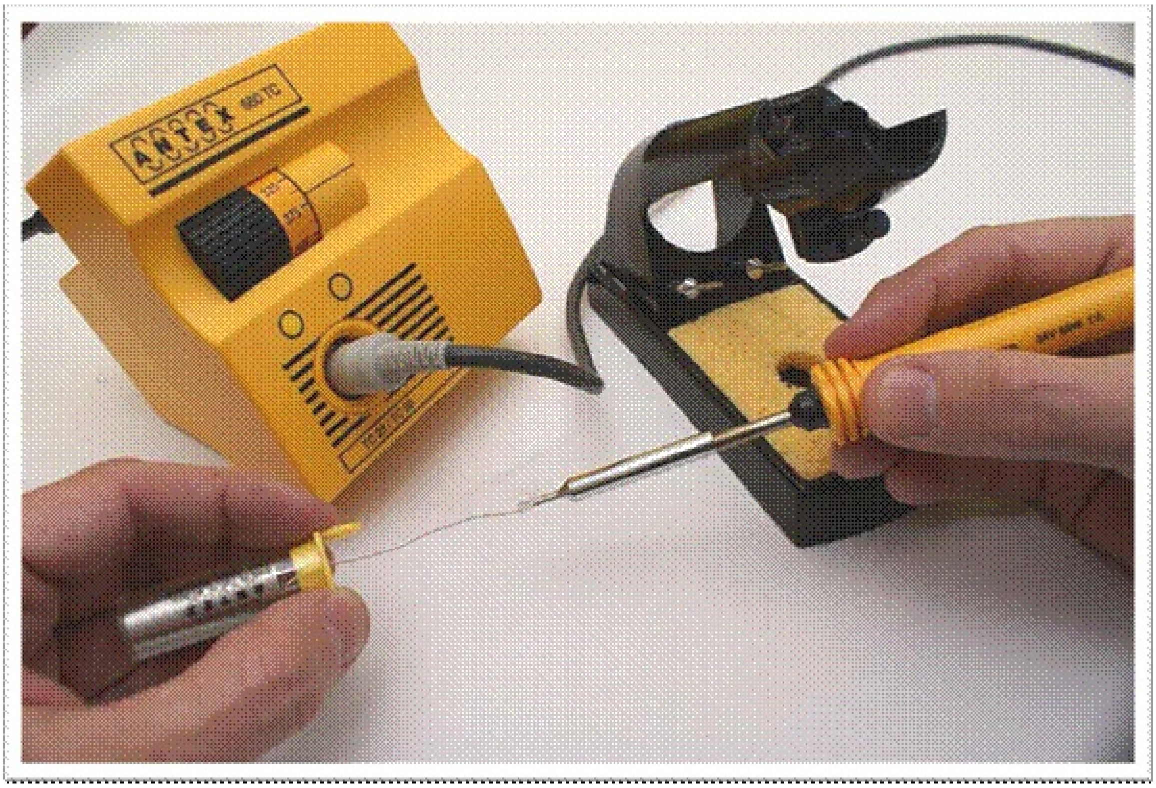
As already explained, cleanliness in soldering is a major factor in obtaining successful results. A soldering iron stand usually has a sponge that is dampened – it wants to be quite damp but not running wet, so squeeze out any excess.

^^ Dampen the sponge but don't soak it unduly. Note the hole, which gives an edge to wipe tip with.



^^ *An Antex soldering iron tip. It simply slides onto the iron's heating element. Only the extreme end is wettable and will accept solder: the tip should be kept nice and shiny.*

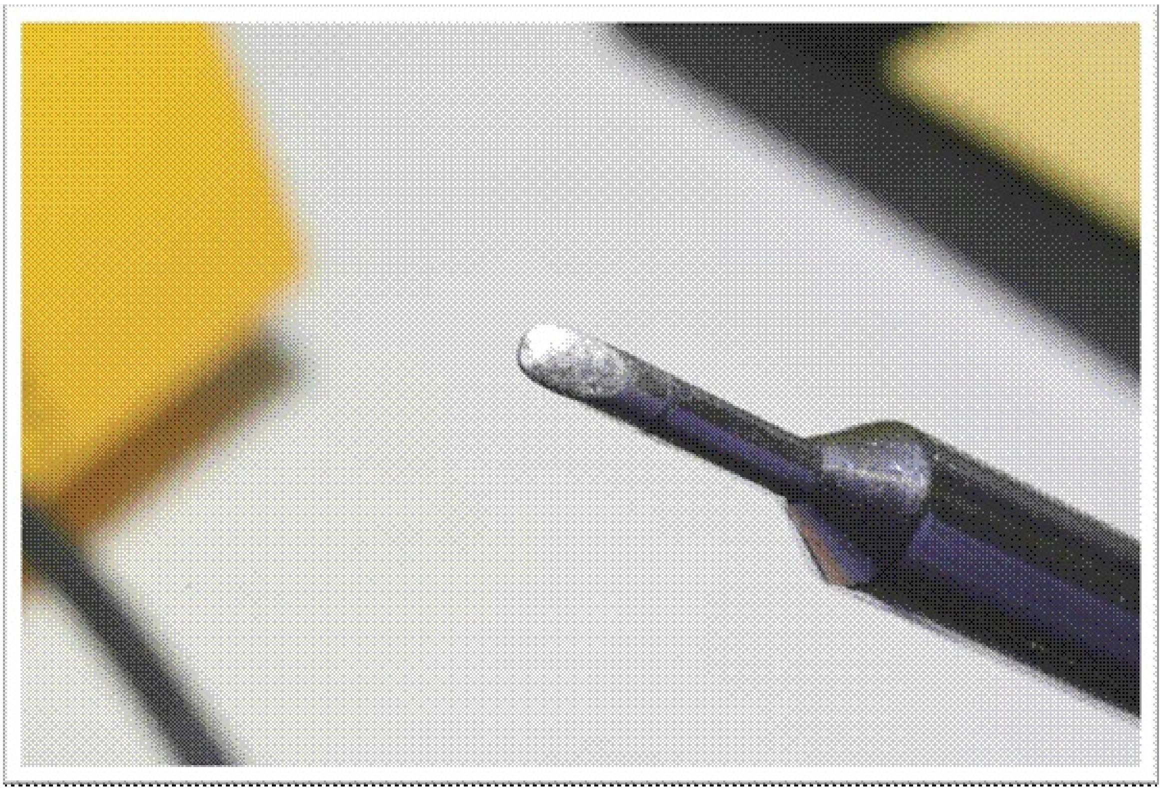
Soldering iron bits are typically iron-plated to resist wear, then chrome-plated to prevent molten solder being deposited on them, with the extreme tip being "wettable" to work with molten solder. Before using the iron to make a joint, the hot tip must be "tinned" with a few millimetres of solder*: you should always flood a brand new tip with plenty of solder to tin it immediately, when using it for the first time*.



^^ *Tinning the tip ready for use: apply a few millimetres of solder to the hot tip.*

Wipe off excess solder using a damp sponge and it's ready to use. That's why sponges have a hole or well in them – the edge acts as a wiper and the hole catches excess solder.

A useful tip: after tinning the bit, just before using the iron it helps to re-apply a small amount of solder to a clean tip, to improve the thermal contact between the tip and the joint. The molten solder fills the void between the materials and the iron tip, to help transfer heat better so that the solder flows more quickly and easily.



^^ *A tinned tip should look like this, ready to make the next joint.*

It’s sometimes better to tin larger parts as well before making the joint itself, but this is not generally necessary with p.c.b. work. Small tinlets of special paste are available onto which you dab a hot iron - the product cleans and tins the iron ready for use. It’s useful in extreme cases where the bit has some stubborn contamination.

I find special Tip Tinner &Cleaner products to be very useful: gently abrasive in action, they help to clean dirty bits and keep them in good condition. Use them for removing stubborn contaminants, but don’t overdo it.

^^ Tip Tinner and Cleaner is a useful aid to maintaining a soldering iron bit …

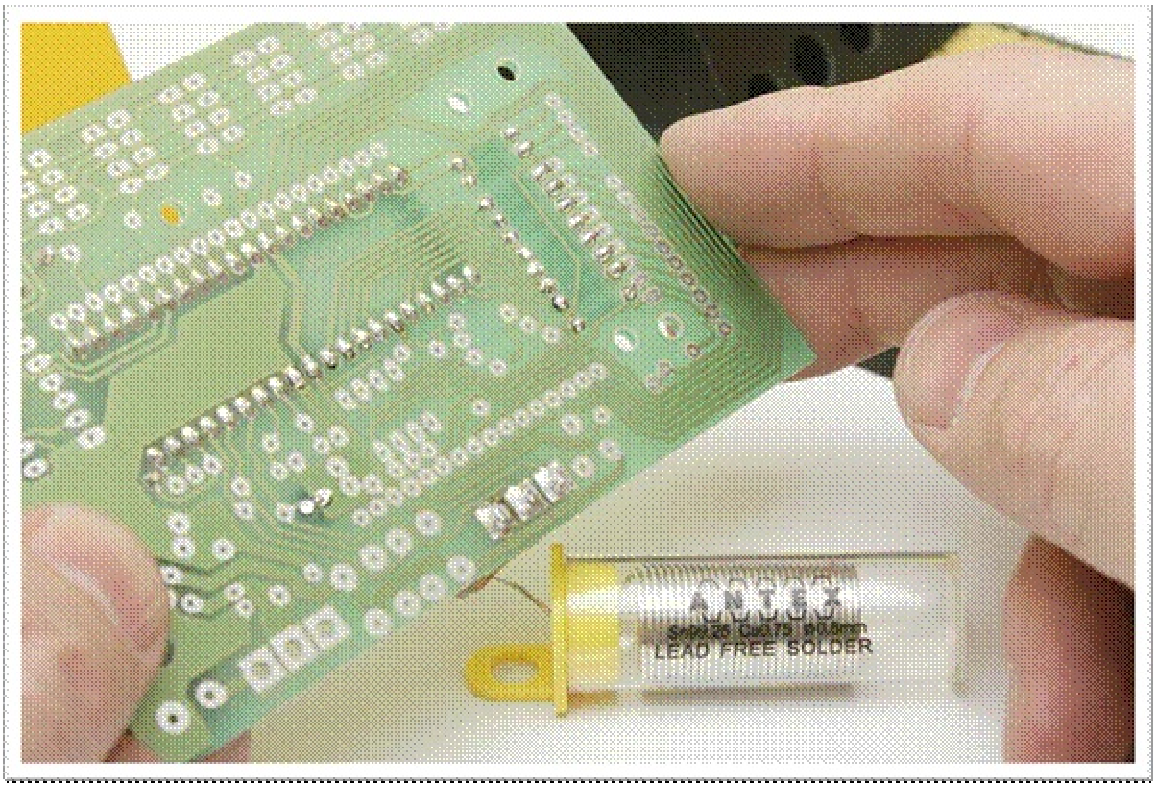
^^ Just press the hot iron onto the solid paste and scrub it around a little. The tip will be cleaned, tinned, and made ready for use.

The move to lead-free solders (see next chapter) has had some effect on the life of soldering iron bits, with increased wear and corrosion noted due to the higher temperatures and the fluxes found in tin-based solders. You can therefore expect bits to wear out over time. Once the iron-plating is damaged due to oxidation or erosion, the bit is fast approaching its end of life. Never use an abrasive or file to sand down a tip: the iron-coating will be damaged and the iron's core exposed, so the tip will soon be made useless due to erosion.

Having prepared the soldering iron tip ready for use, in the next chapter solder and fluxes are discussed.

Solder and Fluxes

In recent years there's been a move towards using more environmentally-friendly materials in electronic products. EU legislation such as *Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment* (RoHS) aims to reduce toxic heavy metals being sent to landfill. (Look for the RoHS symbol on equipment to indicate compliance.) Due to RoHS compliance, the electronics industry had to change the type of solder it uses in electronic production.



^^ *Electronics solder is supplied in reels or handy dispensers like this.*

Solder comes in various forms including solid bars or pellets for melting in small electric 'solder pots' used for treating the ends of wires with solder. Traditional general-purpose electronics-grade solder is in wire form – starting with so-called "60/40" which contains 60% tin (symbol Sn) and 40% lead (symbol Pb) and is sold in handy dispensers or reels. Although tin-lead solder is now banned in industry, there's nothing to stop the hobbyist from using it but best practice is to use lead-free solder in our work: my advice is to try both, and see which you prefer to work with. "40/60" tin-lead produces lower quality results but is slightly cheaper and perfectly acceptable in hobby circles.

Various diameters of solder wire are marketed. In the UK they're sold in Standard Width Gauge (SWG) sizes, typically as 18SWG (1.2mm) or 22SWG (0.7mm). The latter is fine for almost all hand-soldering of printed circuit boards or general electronics. For larger solder joints (e.g. larger switch or motor terminals), 18SWG solder would be better as more solder can be dispensed more quickly.

Lead-free solder is universally available and contains typically 99.7% pure tin and 0.3% copper (symbol Cu). It needs a higher melting point which makes it slightly more difficult to work with, but standard soldering irons will cope with it well. Antex lead-free

solder (Sn 99.25 / Cu 0.75) is a good compromise at 0.8mm diameter and is sold in small dispensers.

Other solders are produced for specialist work, including aluminium solder (Alu-Sol®) and another solder variant used by professionals is Multicore “Smart” wire which contains a small amount of pure silver (symbol Ag). It produces very clean results and is often associated with SMD (surface mount devices), though some engineers also use it for routine p.c.b. work for producing the best possible finish by hand. As “Smart” wire contains lead it is not RoHS compliant.

An interesting variant is **Eutectic** solder, which is 63/37 Tin/Lead. It goes instantly from solid to liquid when melted and is particularly good for hand-soldering. An almost-equivalent lead-free product would be Stannol Flowtin TC or TSC solder.

The low-down on fluxes

When melting solder with a soldering iron, oxides of metal are produced as a result of the high temperatures involved. Unfortunately, these oxides contaminate the metal surfaces being soldered, which interferes with the flow of molten metal and the production of a good quality solder joint.

All electronics-grade solder wire therefore contains an additive called “flux” which helps the molten solder to flow more easily over the joint. It does this by scrubbing away the oxides which arise naturally during heating, and it will often be seen as a pungent brown fluid bubbling away on the joint, accompanied by some fumes.

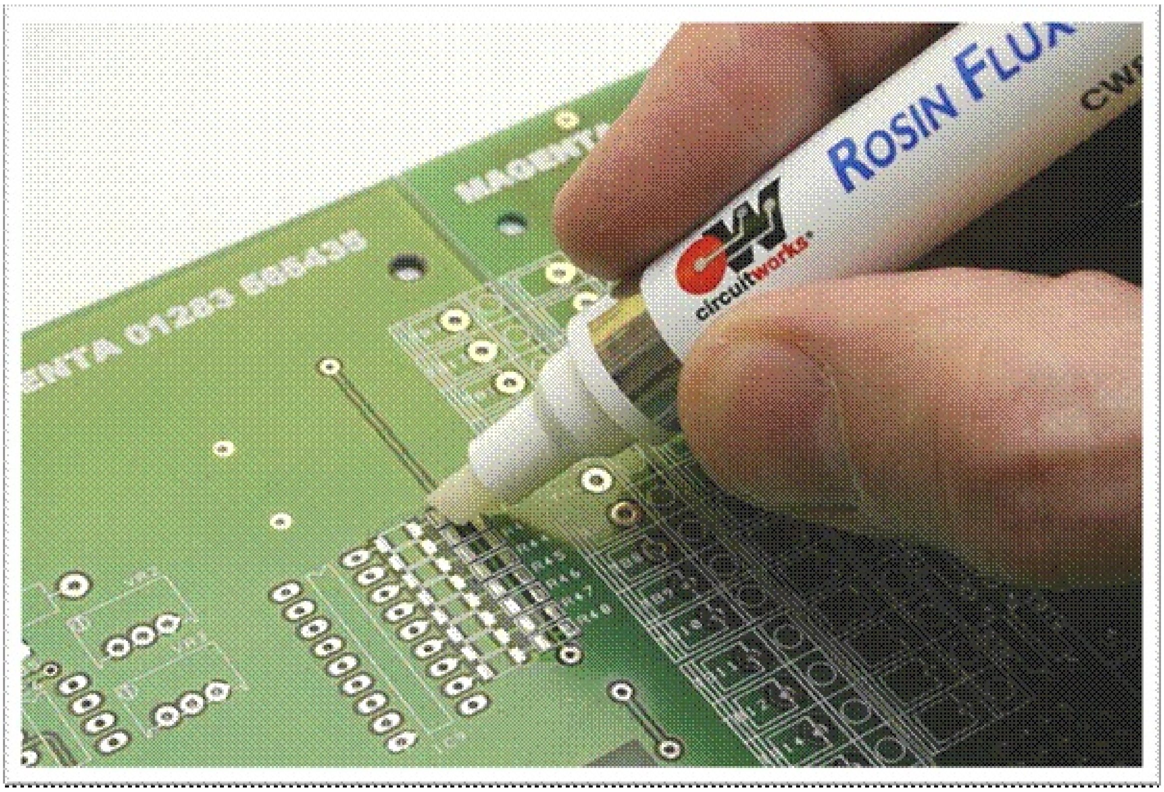
Those coming into electronics from other industries should note that flux is already contained within “cored” electronics solder and on no account should any acidic flux be applied separately before using the soldering iron. Plumbers, for example, apply flux paste to copper pipes before soldering them, but electronics-grade solder wire already contains a flux and extra flux is almost never needed. Electronics is no place for acid fluxes!

^^ *A close-up of electronics-grade multi-cored solder. Five cores of rosin flux can be seen running through it.*

For almost all electronic hand assembly, solder wire containing “Rosin flux” is used. Cores of flux run through the solder wire like letters running through seaside candy, and they prevent the hot area from being contaminated by oxides, otherwise solder would never flow properly and the result would be an incomplete and unreliable joint.

Flux dispensers and Colophony

Flux dispenser pens are sold that allows special liquid flux to be applied separately onto a work area. These might be handy for difficult or challenging jobs to help solder to flow better: adding more flux this way won't do any harm and may help a solder joint to be made more quickly and reliably. In my hobby electronics, there's hardly ever been a time when I felt the need to apply extra flux but it's useful for some very tricky or demanding jobs.



^^ *For more demanding work, a flux dispenser pen allows additional flux to be applied*

For example I've used specialist Chemtronics flux dispenser pens on tricky, extra-large solder joints involving very thick wires for lead-acid battery connections where I really struggled to make the solder flow properly. You might also use them in micro-electronic surface-mount work. The extra flux can only help, but for the rest of the time rosin-flux core solder wire contains sufficient flux and that's all that you'll need.

^^ *Colophony or rosin flux is available in small tinlets if you want to prepare your own liquid flux.*

One thing that many seasoned electronics enthusiasts will recognise is the distinctive smell of rosin flux: its intense woody pine smell is not unpleasant, and flux fumes themselves are not known to be harmful but solder smoke can be an irritant, especially if you suffer from asthma or other respiratory conditions. (I dealt with solder fume extraction earlier when soldering irons were outlined.)

Rosin flux is also known as **Colophony.** It's an amber resin that's glassy and brittle like sugar candy, distilled from the resins of conifers (mainly pine trees) and it's worth knowing about. For electronics use, Colophony is available in individual tinlets of solid resin (e.g. *Kolophonium* in 20g tins by Donau Elektronik GmbH, sold by Westfalia or Conrad).

As an aside, the resins of various trees are used in incense burners: placing a few fragments on a charcoal burner produces intense delicious fragrances of pine, frankincense or forest but you still wouldn't want to inhale the smoke or fumes directly.

Solids of Colophony can be dissolved to make a semi-liquid flux, for dipping or applying manually prior to soldering. To make your own rosin flux from solids of Colophony, chip off some fragments and crush them into a small tinfoil dish, then apply some isoproponal alcohol (start with 2 parts solvent to 1 part Colophony) and let it dissolve over about 20-30 minutes or more.

^^ Chip off some solids of colophony and put them in a small tin foil dish

^^ Add e.g. x 2 volume isopropanol alcohol and allow the solids to dissolve. Experiment as needed.

^^ *The resulting flux can be very sticky so handle with care and do not spill.*

In this form it can be applied directly with a brush or dropper to areas prior to soldering. In an open dish, after a day or two the solvent will mostly have evaporated to leave an extremely sticky resin that should be handled carefully: it's no co-incidence that Colophony is also used in adhesives and varnishes, and different grades of Colophony resins are used to treat violin or double-bass bows to add friction to bow hairs! Try experimenting with different ratios of solvent and making some up and storing it in an old nail varnish bottle with brush, or generally do what works for you.

Unused Colophony crystals can be reformed into their storage tinlet by warming carefully with a hot air gun, but don't overdo it. You can also use flux cleaners or PCB solvent cleaners if you want to remove traces of excess rosin flux after soldering: these are left behind as a brown deposit and are otherwise harmless.

The subject of using your soldering iron to raise the temperature of the materials is discussed next.

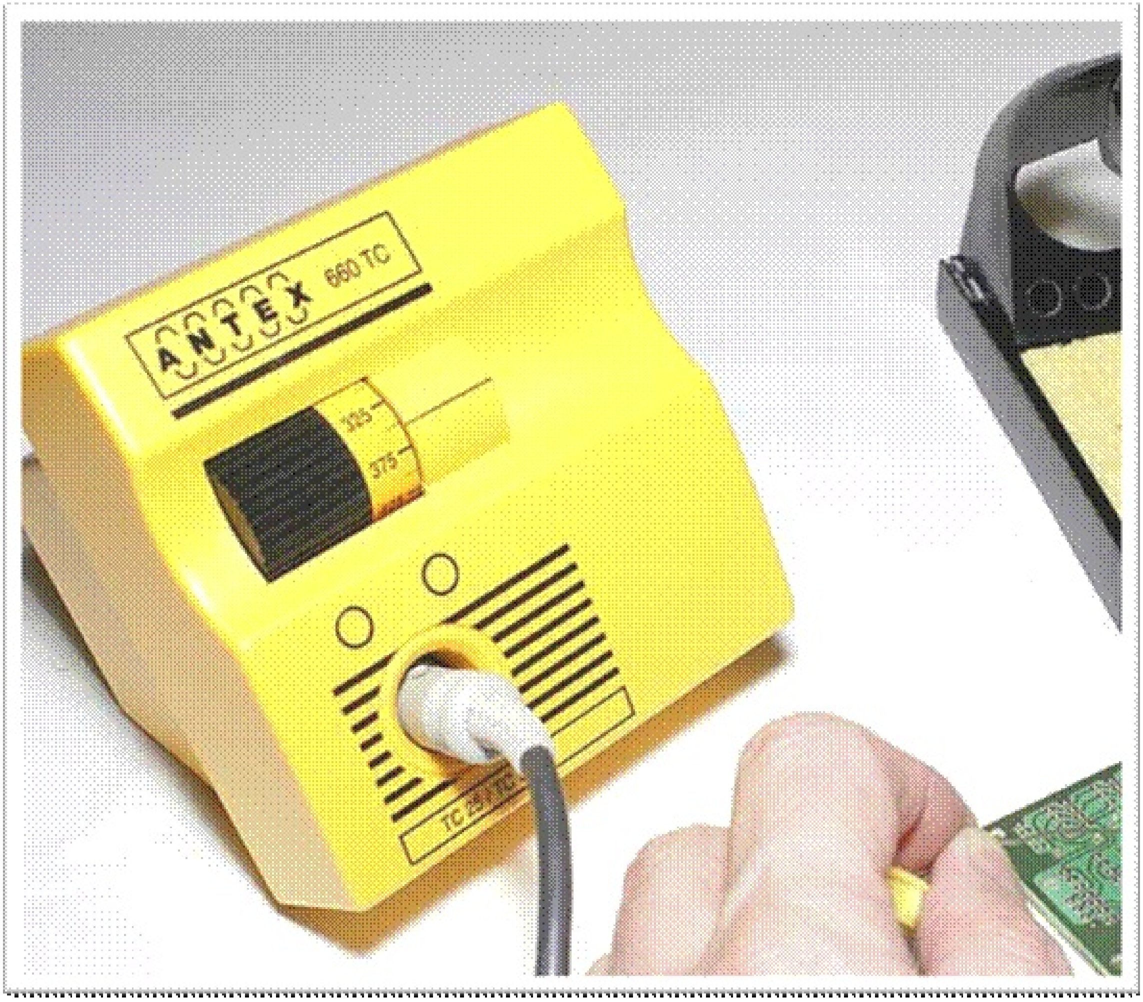
Temperature flow

This aspect takes a bit more understanding, but with practice you'll soon understand how temperature flows within a workpiece being soldered and how you have to harness it properly. After ensuring all parts are clean and the soldering iron is ready to go, the next step to successful soldering requires that the **temperature** of **all** the parts is raised to roughly the same level, before solder can be applied.

Imagine the most basic task of soldering a simple resistor onto a printed circuit board: the copper p.c.b. and the resistor lead should both be heated *together* so that the solder will flow readily over the joint. Later I'll show the precise stages step by step.

A beginner will often mistakenly just heat one part of the joint (e.g. a resistor's wire protruding through a printed circuit board) and hope that the resultant "blob" of solder will be enough to tack everything together. That's completely wrong, because the remaining metal in the joint is cold when molten solder is flooded on to it. The joint will be weak, incomplete or unreliable. Flux will not have flowed properly either, so the joint could be contaminated internally.

Another beginner's mistake is to use a soldering iron to carry blobs of molten solder over to the joint, as if to daub solder over it. The secret of success is to control the iron accurately and apply the hot tip onto the workpiece so that it's in contact with *all the parts*. Within a fraction of a second, heat will conduct from the iron and raise the temperature of the entire joint, after which solder can be melted over it. Remove the iron and let the joint cool naturally. It takes some practice with your chosen soldering iron tip to obtain the best heating action, making sure the tip is clean and tinned properly to begin with.

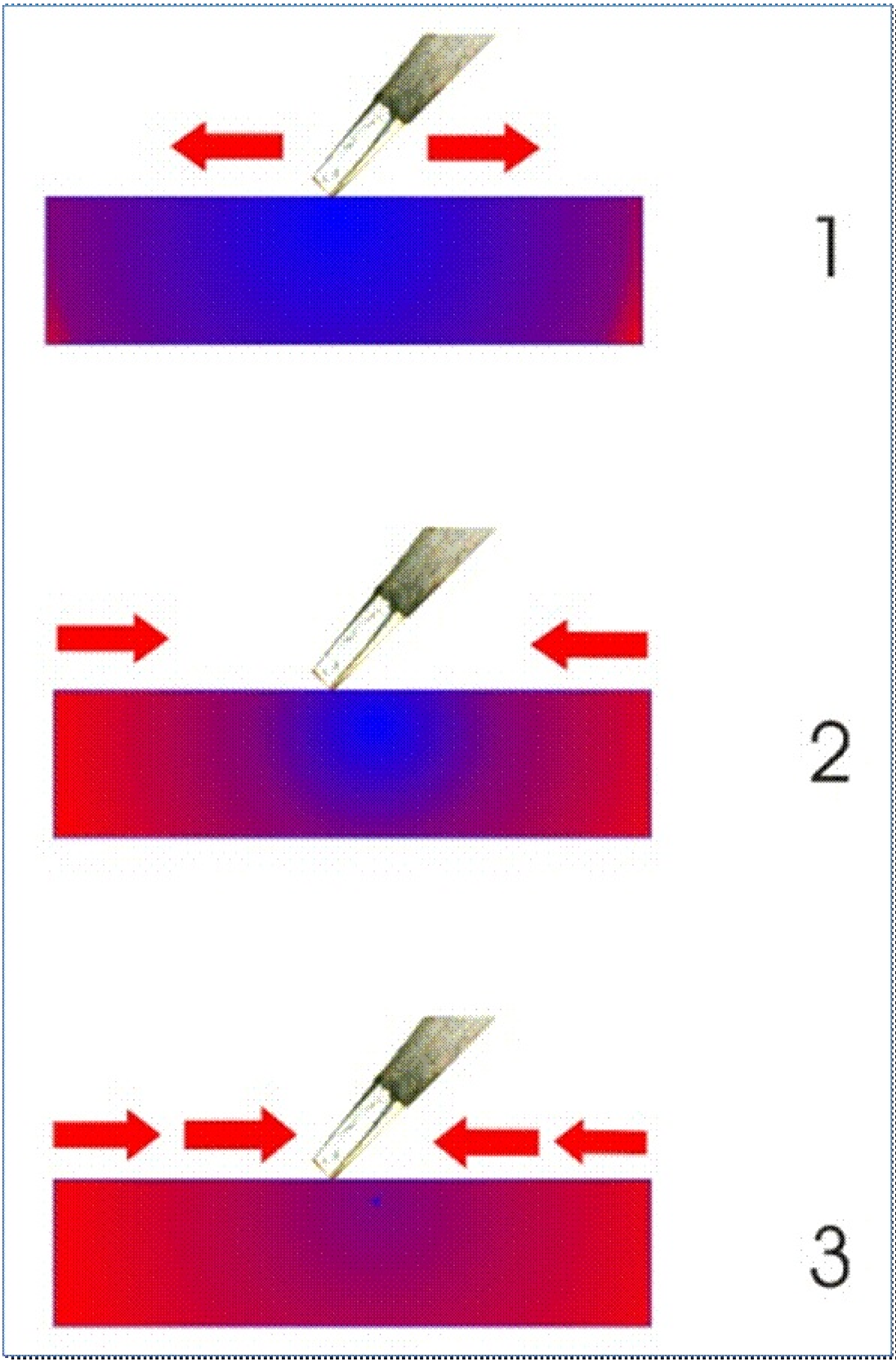


^^ *Set a typical temperature of 330-350 ºC (626-662 ºF) or more, if you have a soldering station.*

The melting point of traditional tin-lead solders is about 190ºC (374ºF) but lead-free tin-based solders require higher temperatures, having melting points of typically 201-227 ºC. As Antex reminds us, the melting point is *not* the temperature of the soldering iron tip: instead you should set a temperature that ensures the solder melts *instantly* onto the tip. Fixed-temperature soldering irons have no adjustability but they'll cope just fine with either type of solder. A soldering station usually has a variable control that gives more control in different circumstances. In practice the iron tip temperature should be set for typically 330-350 ºC (626-662 ºF) or maybe a little more if using lead-free solder.

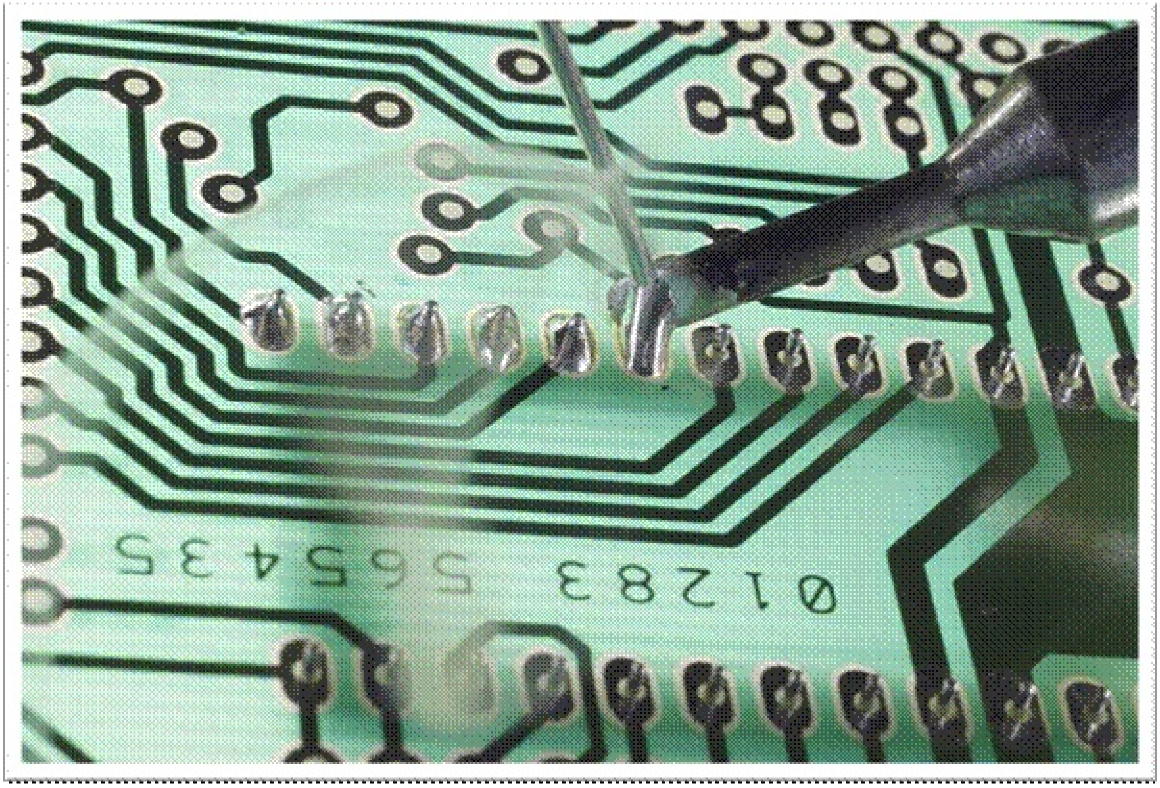
Now is the time…

The next diagram shows what would happen if you applied a hot soldering iron to an imaginary metal block. In step (1) heat travels out of the iron into the cold metal block, which starts to warm up starting at the edges. Gradually (2), the whole metal block's temperature rises until the middle of the block finally rises in temperature as well. In effect heat is now travelling back “towards” the iron tip, until finally (3) the whole block is at the same temperature as the iron. At this point solder could now be applied.



^^ How metal in the joint actually "sinks" heat away from the tip to begin with. Then heat moves back towards the tip until the solder's melting point is finally reached.

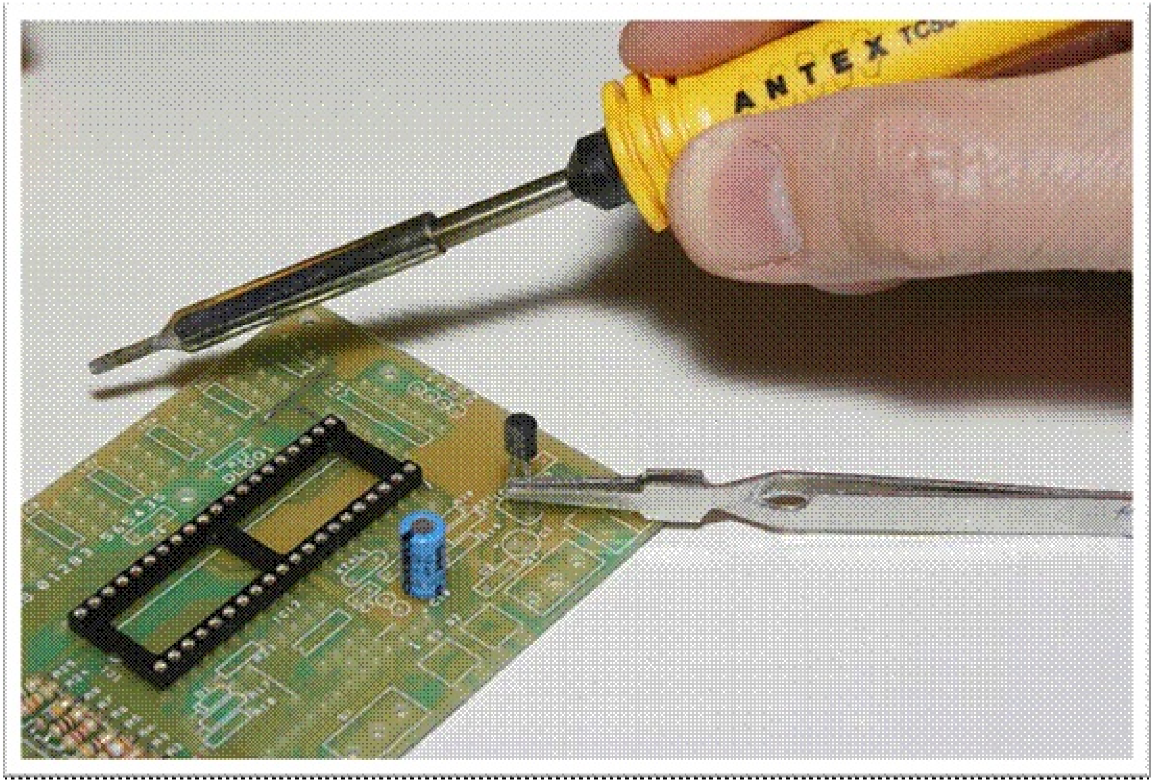
You'll notice this effect as a time delay when soldering any joint. The "working area" of the iron's tip gets **cooled** to begin with, because the metal in the rest of the joint is sinking heat away from where it's most wanted. Only after the whole joint has risen in temperature can solder be melted onto it.



^^ *Soldering a small p.c.b. joint*

With experience, you’ll get a feel for how long it takes before you can apply solder. The more metal that is present in the joint, the longer period that heat must be applied for. A small p.c.b. joint takes well under one second to complete. A large metal terminal could take quite a few seconds or more to heat up. As I explained earlier, higher power (wattage) irons cope better with larger workpieces because they recover more quickly and are more “unstoppable”, making it easier for them to heat larger workpieces without cooling down so much.

If you apply solder too early, it won’t melt properly and the result will be a grey, crystalline joint caused by the solder’s melting point temperature not being reached and the flux not having flowed properly. Semiconductors must be soldered as rapidly as possible as they are heat-sensitive, but they’re a lot more robust than they used to be.



^^ *A clip-on Antex heat shunt fitted to a transistor leg, helps prevent thermal damage due to overheating when soldering it in place. Less essential these days, but beginners find them re-assuring.*

Until they have gained some practice, novices sometimes buy a small clip-on heat-shunt (photo) which resembles a pair of aluminium tweezers. In the example of, say, a transistor, the shunt is attached to one of the leads near to the transistor's body. Any excess heat then diverts up the heat shunt instead of into the transistor junction, thereby avoiding the risk of thermal damage. Applying far too much heat may destroy the part or damage the p.c.b. foil which may lift away from the board.

In due course constructors learns to judge how much solder should be applied to any particular joint. An ideal p.c.b. joint is very slightly concave in shape. If not enough solder is used, the result may be an incomplete joint which may cause an intermittent fault later on. An excess of solder – shaped like a ball bearing - is an unnecessary waste and in extreme cases may cause short circuits, especially on densely-populated boards. There is no need to add more solder "for luck". Professionally-produced p.c.b.s have a green *solder resist* coating which helps to ensure that solder does not stray onto adjacent pads. As a finishing touch, I usually spray the solder-side of a circuitboard with aerosol spray lacquer afterwards. It keeps the solder joints nice and shiny and helps prevent corrosion.

Some components can create hazards during a soldering operation:

Coin cells and button batteries are commonly used as power, clock or memory backups. If heated excessively they can explode without warning due to the build-up of internal pressure. Spot-welders are used in industry to connect tags to them, but if you need to solder wires to such a cell then it should be done as quickly as possible.

Some **memory back-up capacitors** or **electrolytic capacitors** remain energised for a while even when the circuit is powered down. Molten solder is a perfect electrical

conductor and in some cases the component's contacts could be shorted during the soldering (or desoldering) operation. If molten solder shorts it out then the arcing may cause globules of solder to be spattered outwards without warning, potentially risking eyesight damage.

Always ensure that powered components are electrically inert and discharged before soldering. Cells, batteries and battery packs should not be accidentally shorted during the soldering process, to avoid arcing and solder spatter. Note that electrolytic capacitors can also explode after a while if reverse-connected, so observe polarity closely.

Let's now consider the practical stages of soldering components and wires successfully.

Soldering Step by Step

Earlier I explained the individual factors that affect the quality of a solder joint. These are:

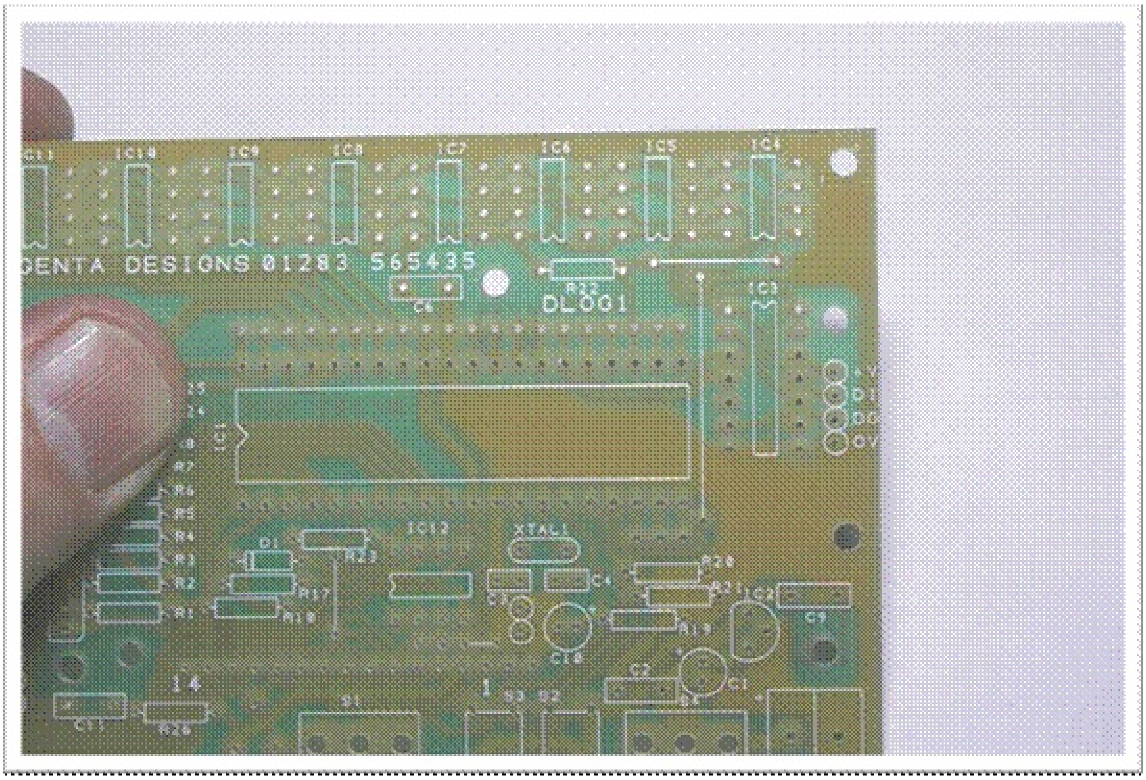
- **Cleanliness** – dirt or impurities drastically hinder good solder coverage.
- **Temperature** – the right level to enable the solder to flow freely!
- **Time** – apply heat for just the right amount of time!
- **Adequate solder coverage** – enough to form a good joint without touching neighbouring areas.

These rules apply whether soldering a p.c.b. or performing other tasks such as interwiring (hooking everything together with connecting wire).

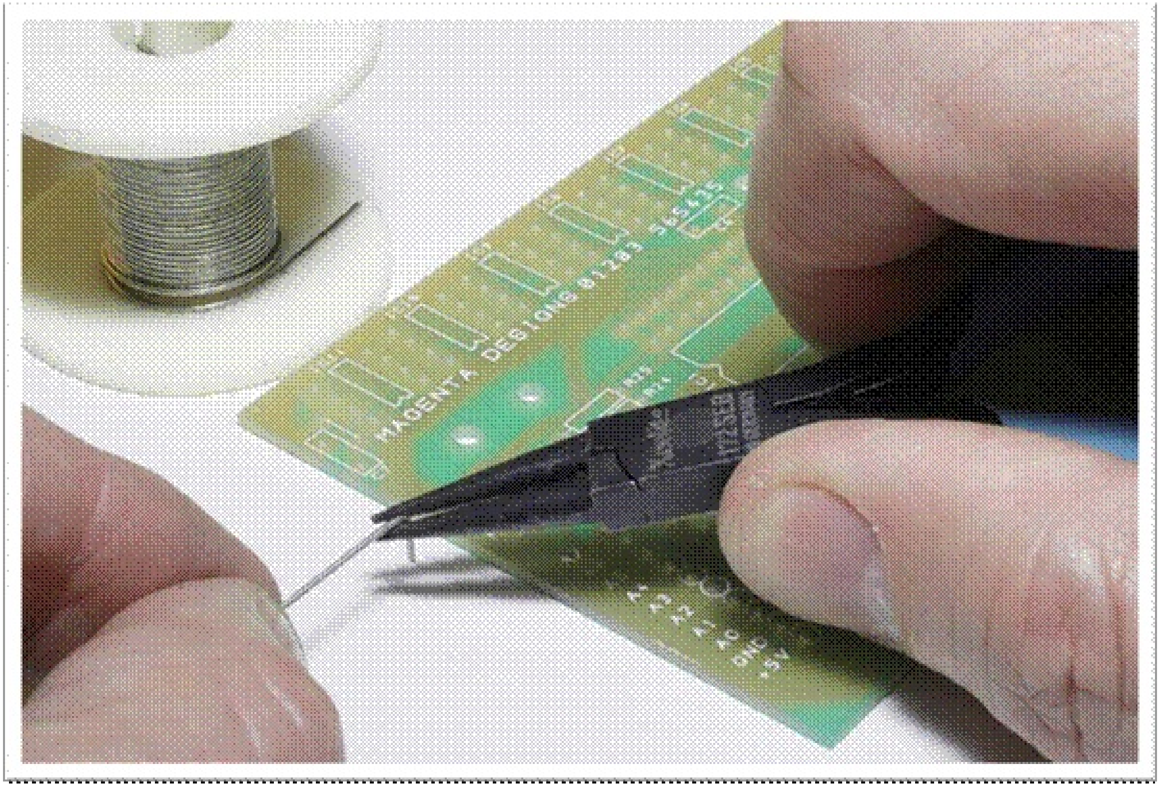
We’ll now summarise the stages of making a typical solder joint – soldering components onto a printed circuit board (through-hole soldering). Most people insert components into the circuit board and simply splay the wires out to hold them in place under spring tension. I find it best to snip excess wire leads off at this stage, to improve accessibility.

- All parts must be bright, clean and free from dirt and grease.
- Try to secure the work firmly to stop parts moving around.
- “Tin” the soldering iron tip with a small amount of solder. Do this immediately, with new tips being used for the first time.
- Wipe the tip of the hot soldering iron on a damp cellulose sponge to remove excess solder or contamination.
- Many people then add a tiny amount of fresh solder to the cleansed tip just before using it.
- Heat all parts of the joint with the iron typically for under a second or so, until it’s heated throughout.
- While heating, then apply sufficient rosin-core solder to form an adequately-covered joint.
- It only takes a second or two at most, to solder the average p.c.b. joint this way.
- Do not move parts until the solder has cooled.
- Remove and return the iron safely to its stand.

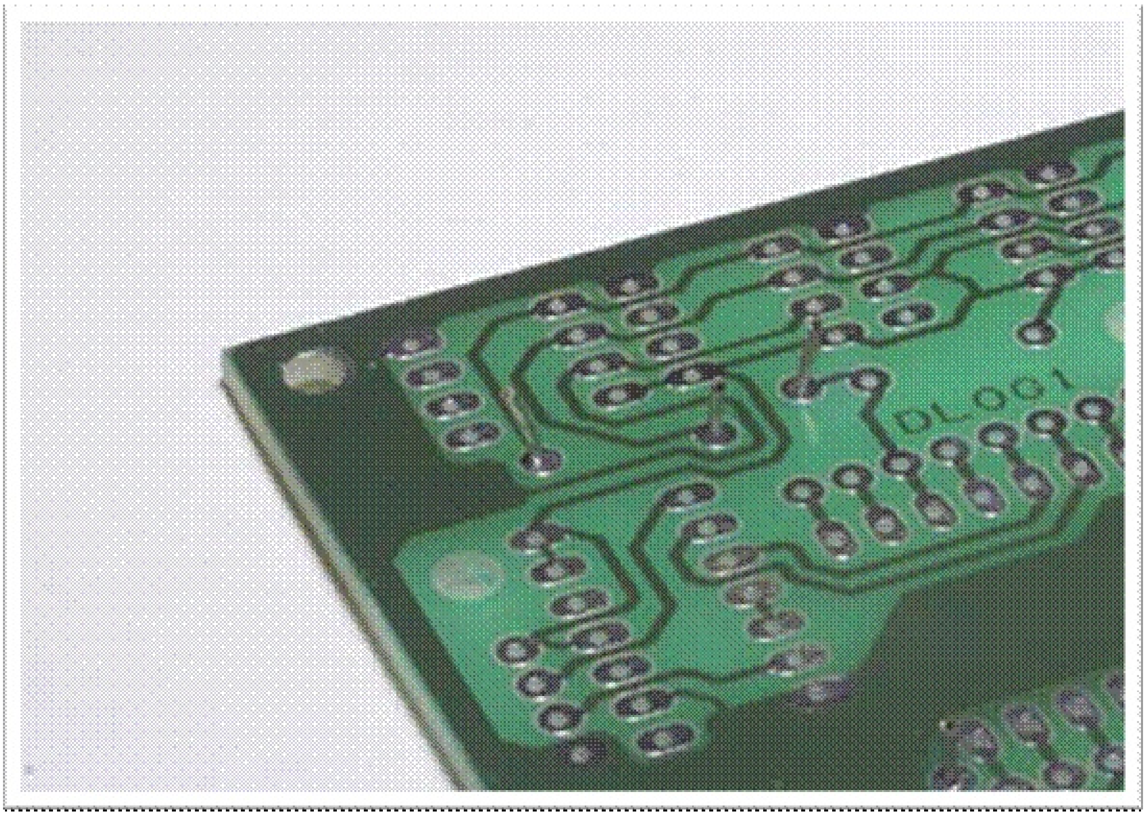
This special photo sequence illustrates these stages. It’s best to start with the smallest, fiddliest parts first when soldering a blank p.c.b., because that’s when you’ve got the most access on the board. Accessibility will be reduced as more components are added, so we’ll start with a simple wire link on a professionally designed p.c.b.



^^ *A typical professional blank p.c.b. – silk-screen printing shows what goes where. The underside has been treated with a green solder resist coating, and the solder pads are ready-tinned to help with soldering.*



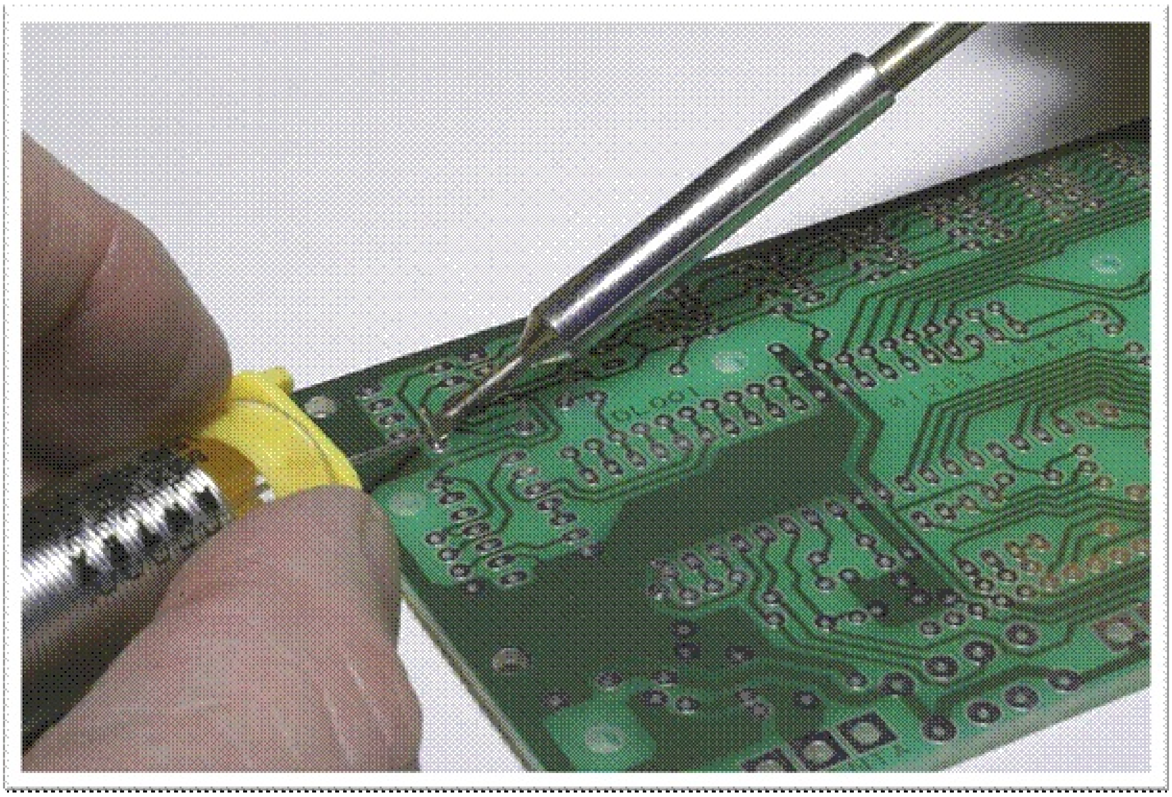
^^ *Preparing a wire link for soldering – cut off some tinned copper wire and bend the ends to fit the p.c.b. correctly. Round-nose pliers (shown) are perfect for this, but ordinary electronics or "radio" pliers will do.*



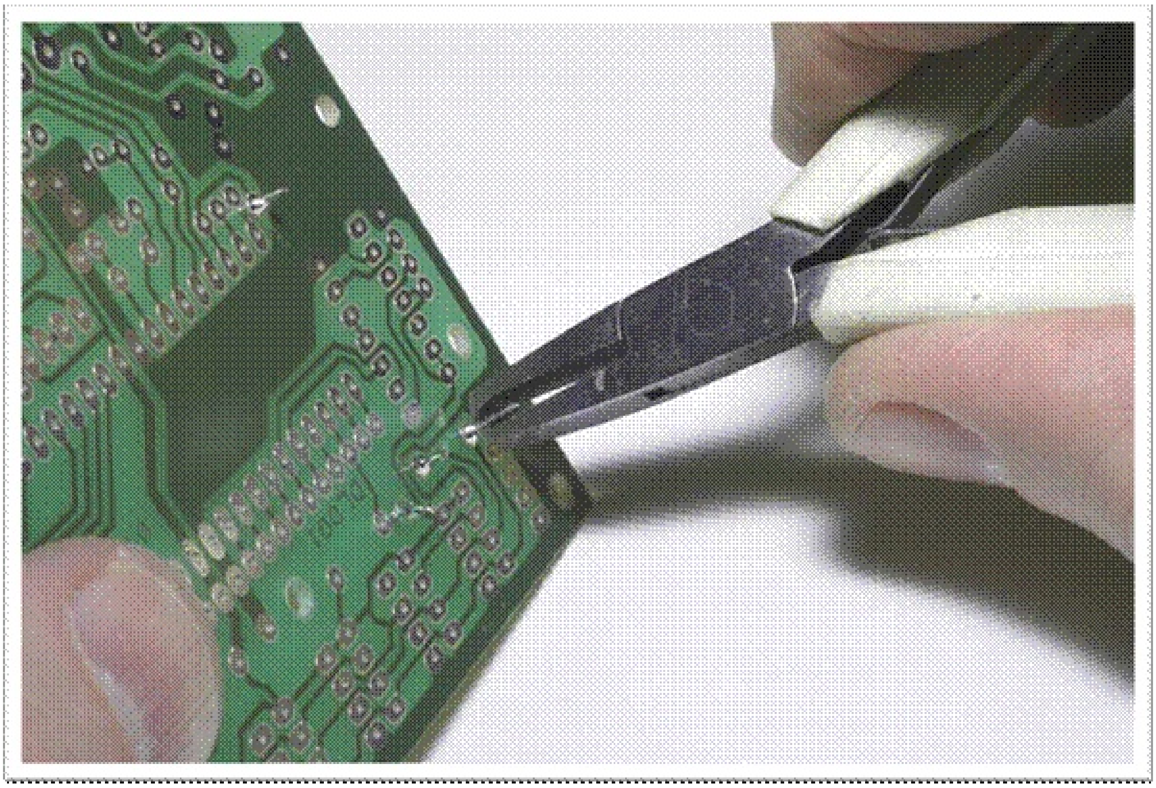
^^ *Wires are prodded through the holes in the board, then turn it upside down to view the solder side. You can then "spring" or splay the ends apart slightly, so they are held in place while you solder them.*

^^ *Wipe the hot soldering iron on the damp sponge to clean the tip. Do this periodically when contamination, flux deposits etc. build up on the iron to keep the tip nice and shiny. Tip Tinner & Cleaner helps too.*

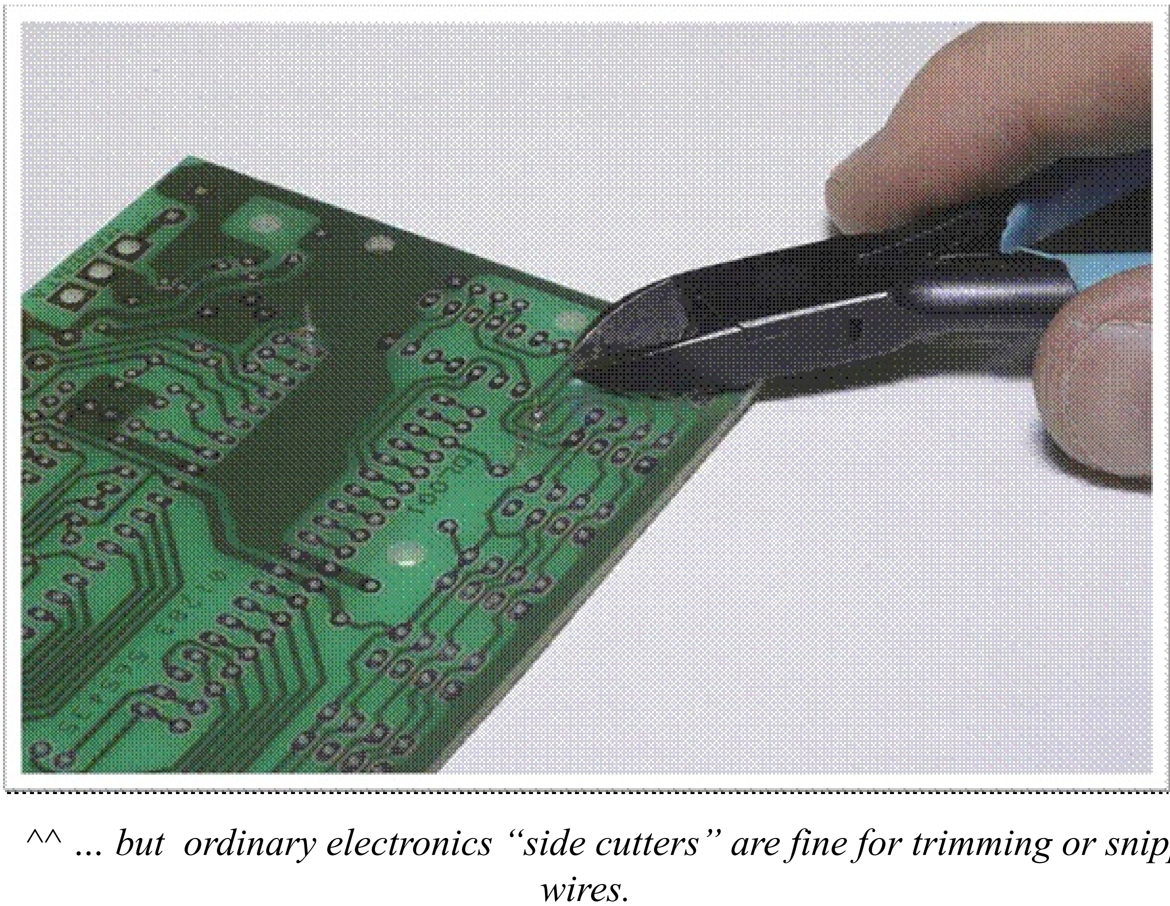
^^ It often helps to dab a tiny amount of solder wire onto the tip, to improve heat transfer.



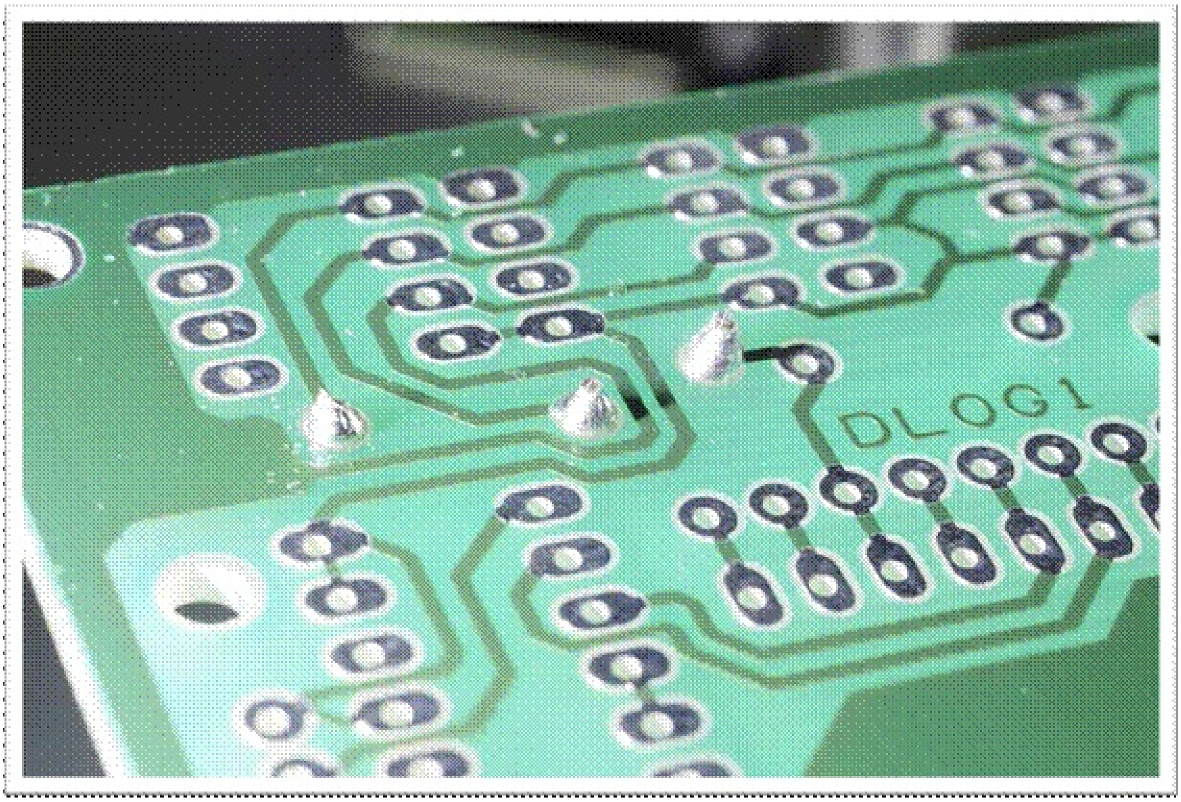
^^ Then apply the soldering iron to heat both the solder "pad" and the wire end at the same time (say <1 second). Apply a few millimetres only, of solder. Then remove the soldering iron immediately and allow the joint to cool down by itself. The green solder-resist coating ensures solder doesn't flow onto neighbouring pads.



^^ These "end cutters" can then be used to snip off excess wire after soldering….

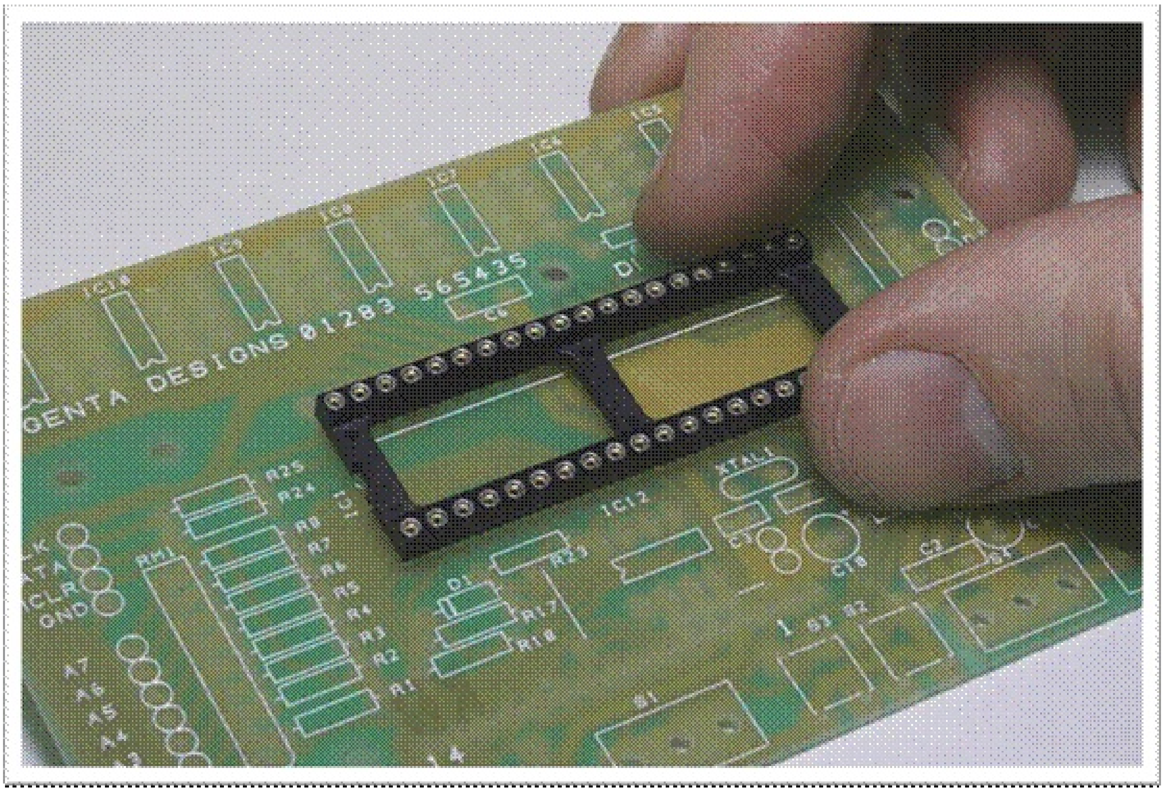


^^ … but ordinary electronics "side cutters" are fine for trimming or snipping wires.

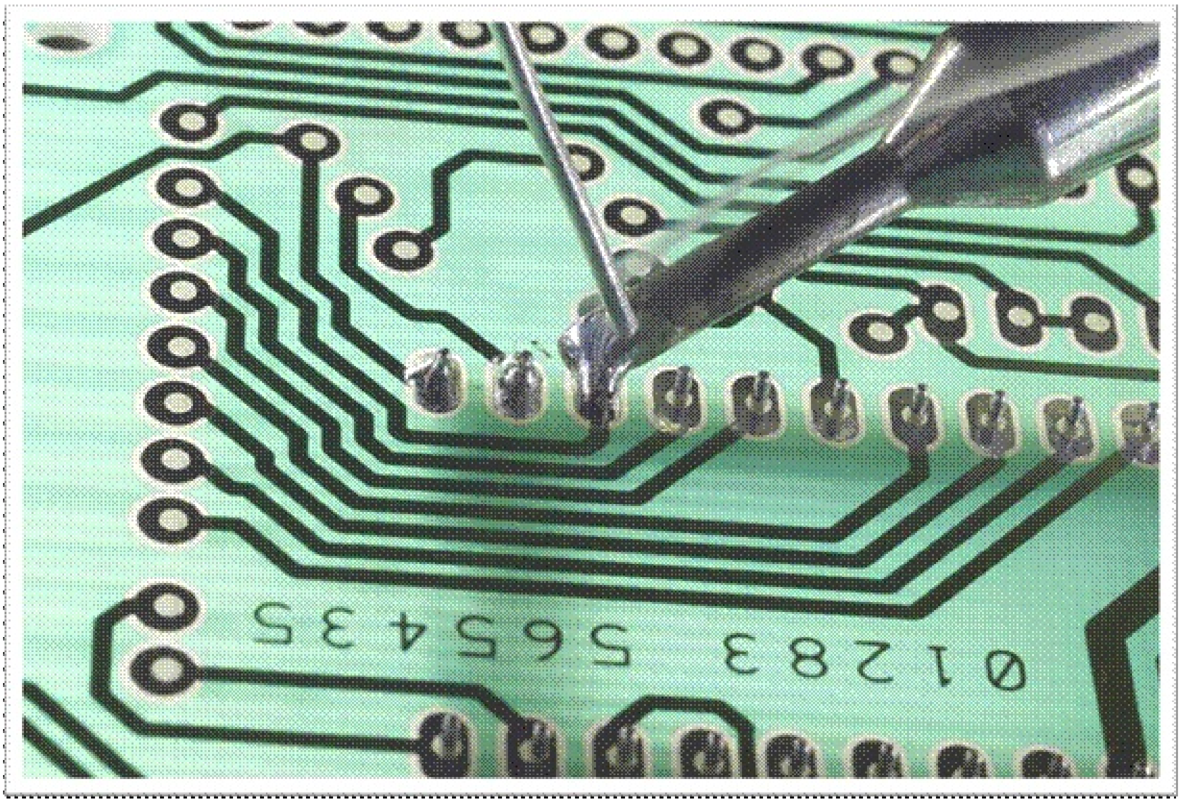


^^ The ideal solder joint should be smooth and slightly concave, quite shiny, not dull or crystalline-looking nor ball-bearing shaped.

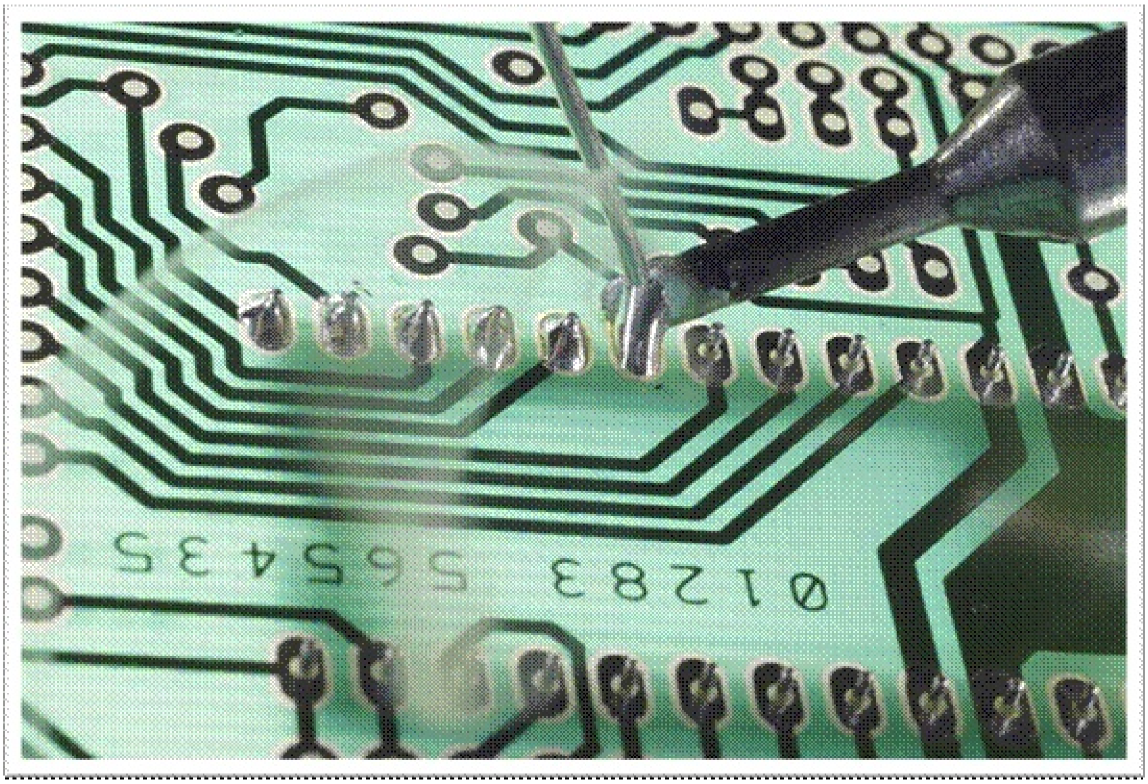
Try to get consistent results in your soldering, but don't worry too much about the lack of uniformity – this is soldering by hand after all, not by precision machinery, and some slight variation is OK provided the solder coverage is good and the soldering is generally clean and effective. You'll improve with practice, that's for sure!



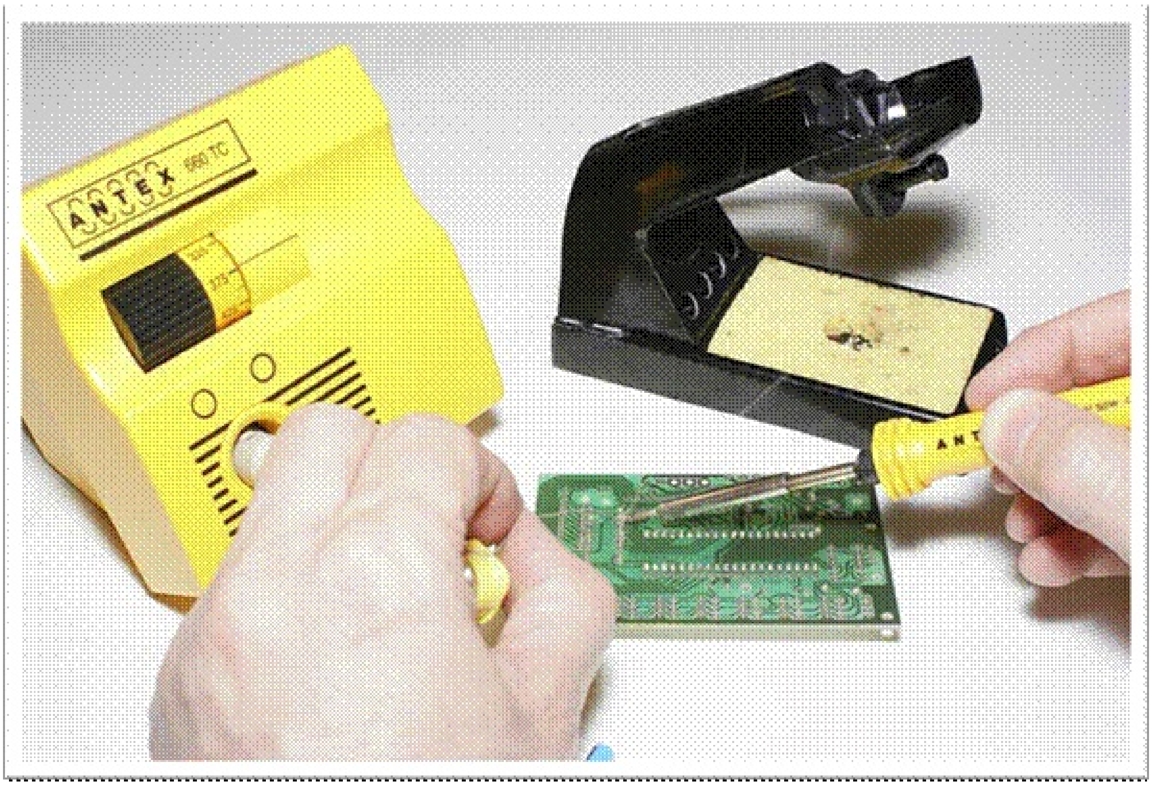
^^ A large i.c. socket can be added next…



^^ Go along the rows of pins and solder them one at a time. See how simple it is! Heat both the solder pad and pin with the iron, and dab on a little solder wire to ensure full coverage. Ensure the socket is flush against the board.

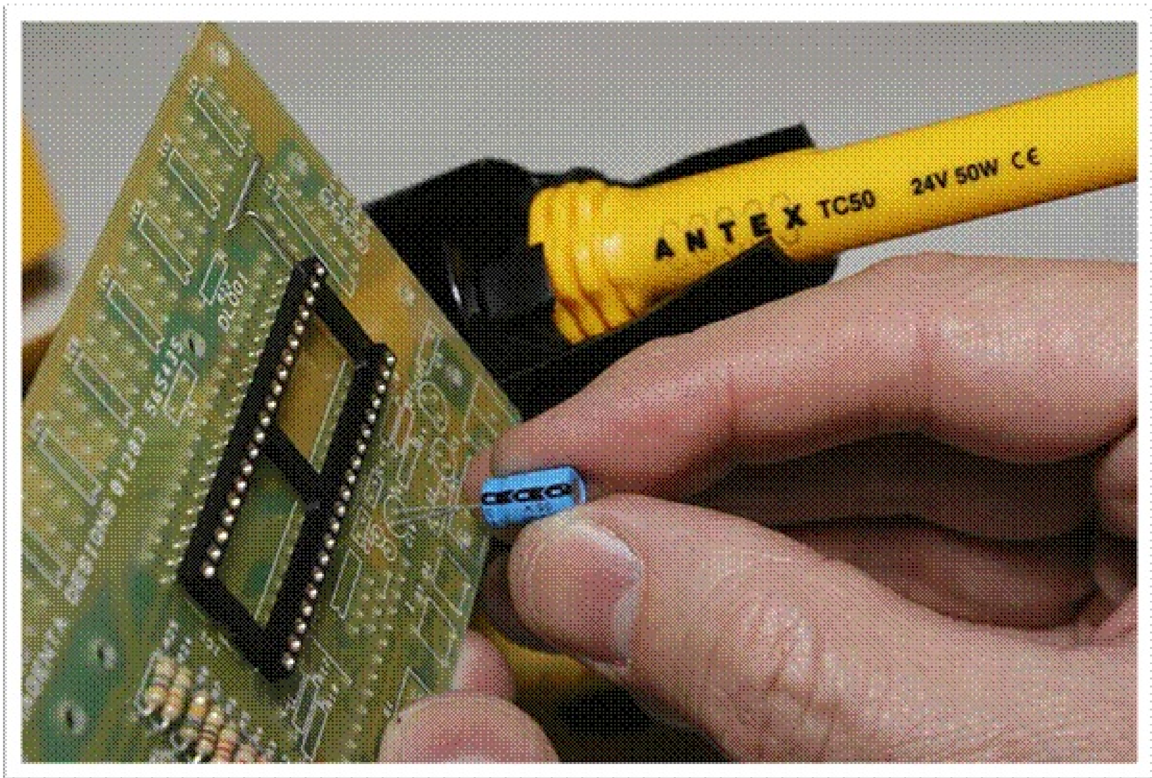


^^ As hardly any metal is involved each pin should take well under a second to solder at most.



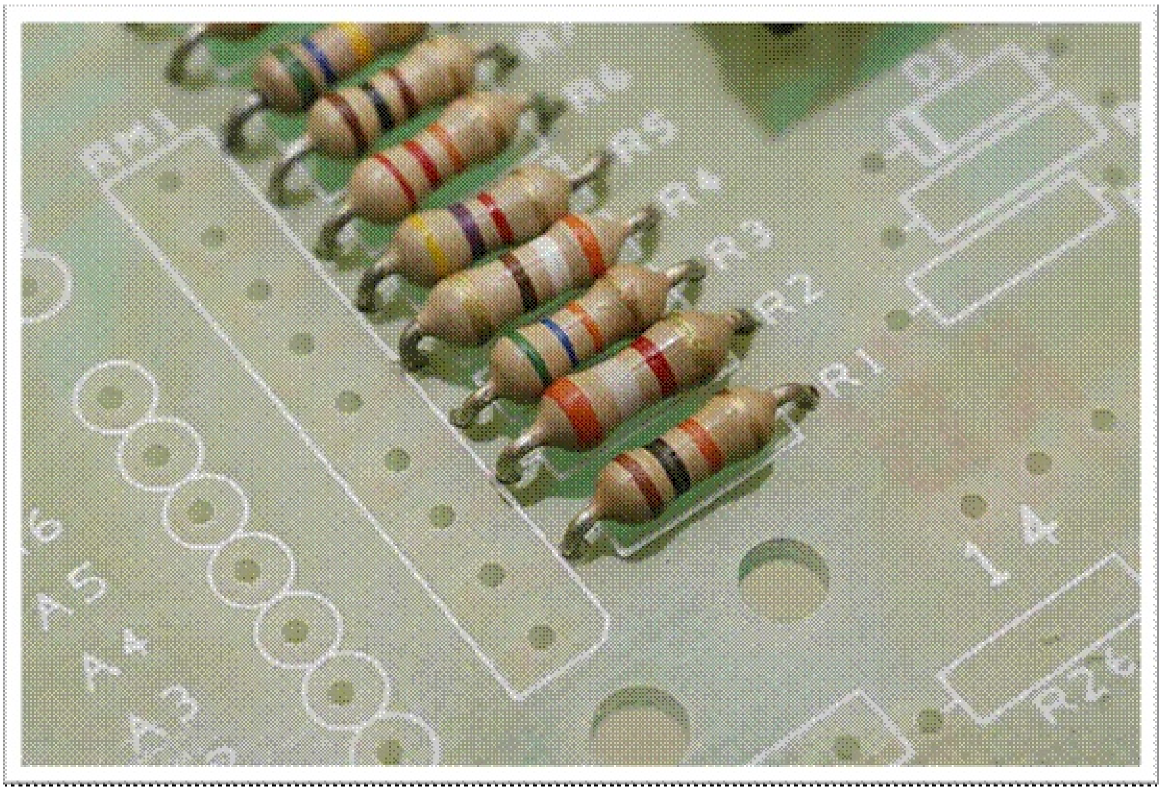
^^ *Continue until the i.c. socket is soldered.*

Once the smallest parts are soldered into place, you can continue to solder the remaining components. It's easiest to handle the smallest so-called "discrete" parts first while you still have plenty of room on the board. I usually solder resistors and capacitors next. The principle of soldering them is just the same as a simple wire link: insert them from above till they are flush on the board, then splay their wires a little to hold them in place, and preferably snip off at least some of the wire to give you more access.

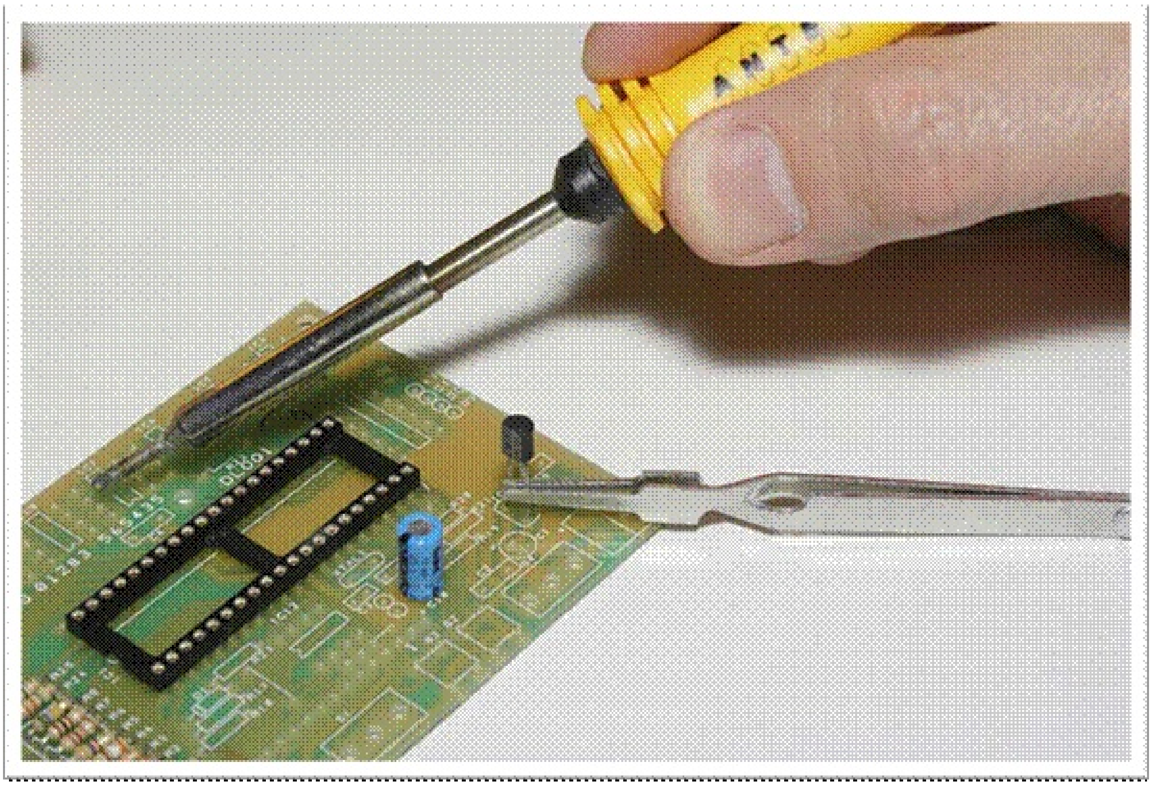


^^ *Continue by inserting "discrete" components from above, splay their wires out*

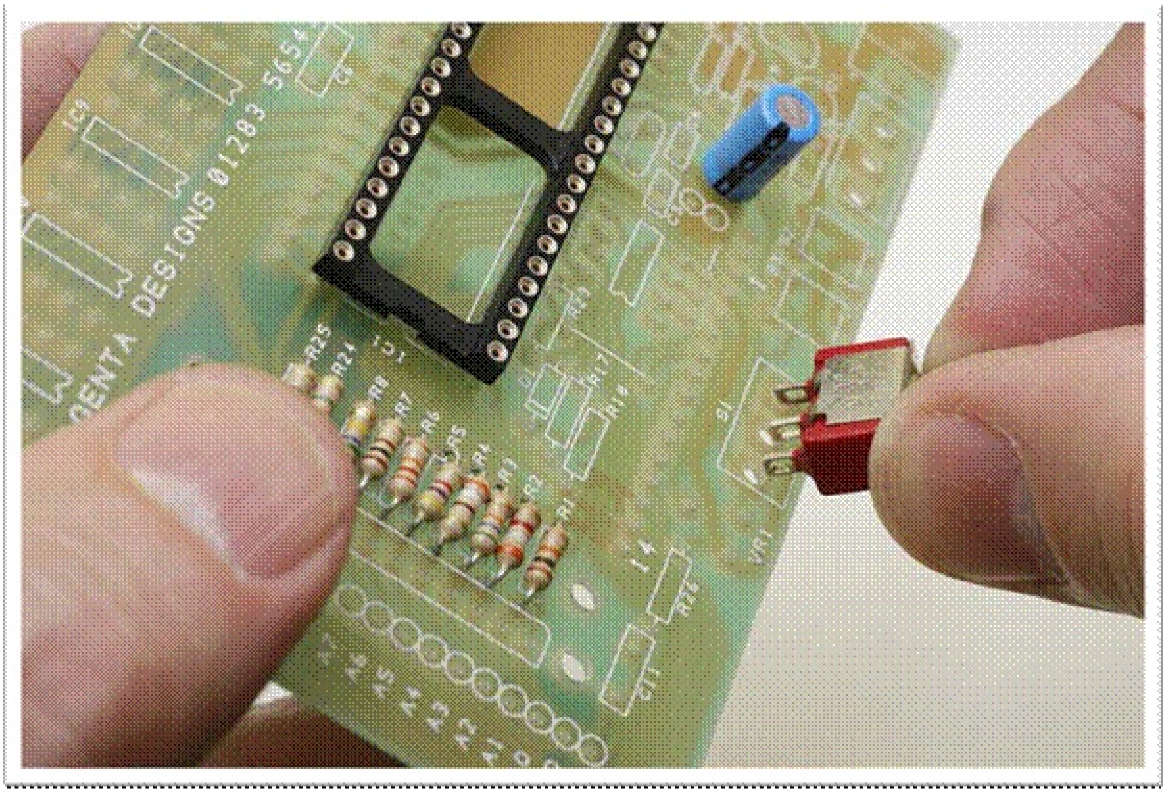
underneath to secure them in place, then snip and solder the joints exactly as before. Some parts like this blue electrolytic capacitor are polarity sensitive (note the – sign), and must be inserted the right way round. Same is true of every semiconductor.



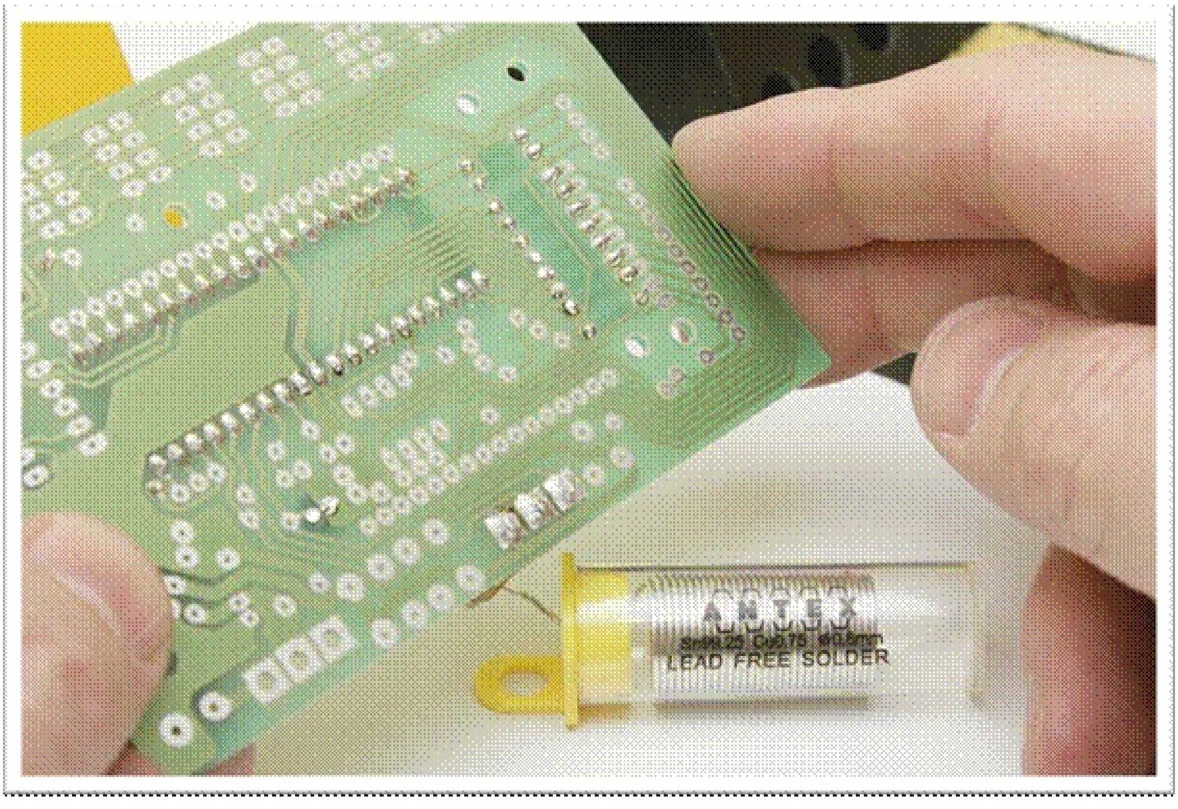
^^ This row of ¼ watt resistors was next. I like to show the colour codes all the same way round, with gold or silver (tolerance bands) on the right for consistency.



^^ This transistor was next. Solder it quickly to avoid damage, and observe polarity correctly, so it is the right way round on the p.c.b. The heatshunt is optional.



^^ Unusually, this toggle switch fitted directly onto the board as well which saved wiring it up. Neat idea!



^^ *As there is comparatively more metal to heat up, it'll take longer to solder the switch terminals, and you'll need more solder as well. Thicker gauge solder is useful at such times. Allow say 2-3 seconds to solder each terminal.*

Don't forget to clean the soldering iron tip on its damp sponge every now and then, to ensure the bit is kept clean and shiny. Later on I'll show you how to correct any problems by desoldering using various techniques. Next, we'll move on from printed circuit board "through-hole" soldering and look at how to handle wires and leads.

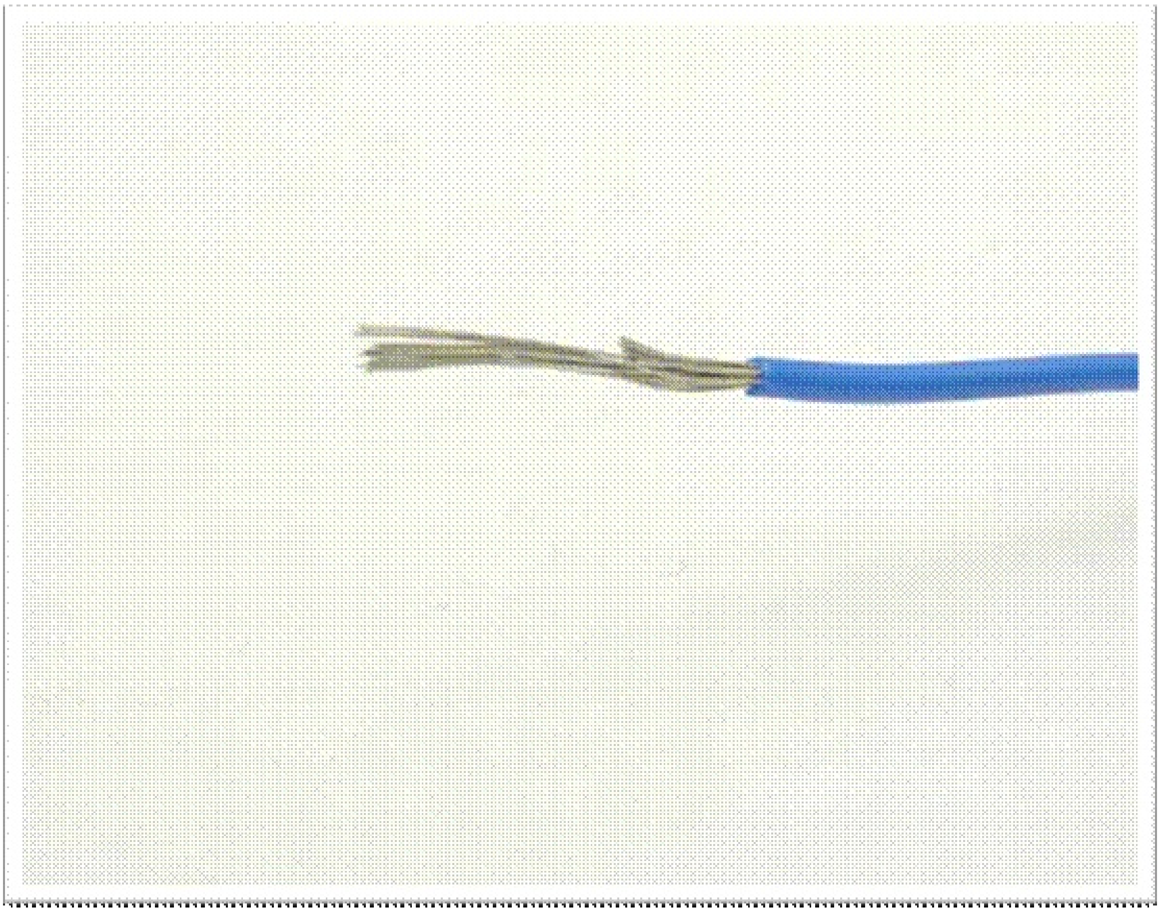
Interwiring – get hooked up!

With practice, through-hole soldering of p.c.b.s will become second nature. There's no substitute for tackling some soldering jobs though, particularly trying a simple kit based on a quality p.c.b. which will boost your confidence enormously.

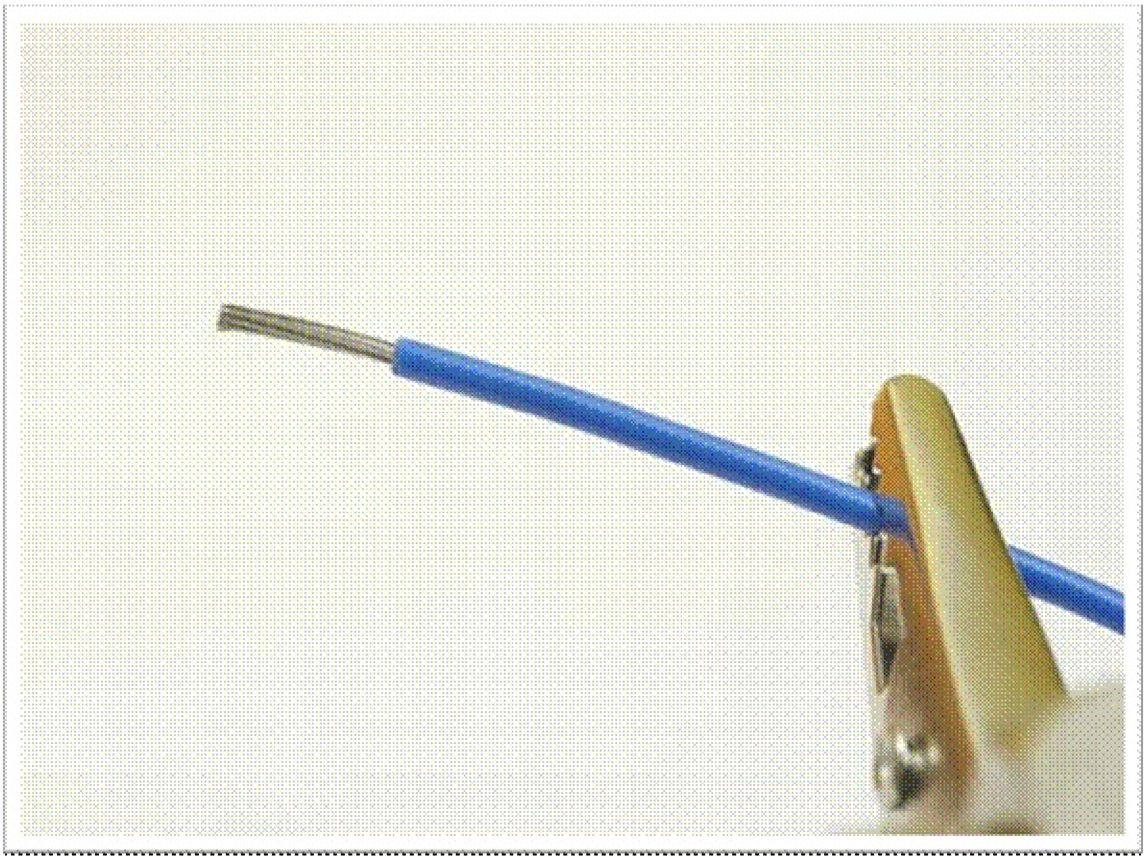
Most electronic devices need connecting up to external components such as battery packs, speakers, l.e.d.s or switches. Usually, multi-stranded connecting wire is used to connect circuit boards and external parts together. Unlike single solid-core wire, *multi-stranded wire* is flexible and vibration-resistant. Hobbyists mainly use 7/0.2mm wire (7 strands, each 0.2mm diameter) for low-voltage hook-ups although much Chinese equipment uses much thinner wires than this. So let's look at some aspects of soldering this type of wire.

In a separate photo sequence I show how a potentiometer (a panel-mounted variable resistor) and a light-emitting diode (l.e.d.) are connected using multi-stranded wire. The same principles of soldering apply to most other components including panel-mounted switches, loudspeakers, buzzers, audio sockets and more.

Components usually have terminals or "tags" to which wires can be soldered. Start by ensuring the component's tags are clean: otherwise solder will not wet properly and the joint will be impossible to solder, so all contamination must be removed. This is especially true of parts that have been in storage a long time. The connections often oxidise or blacken, so clean the solder tags with e.g. an abrasive glass-fibre brush, or a needle file or abrasive paper. Using a glass fibre brush was shown earlier in "Cleanliness and Tinning the Bit".



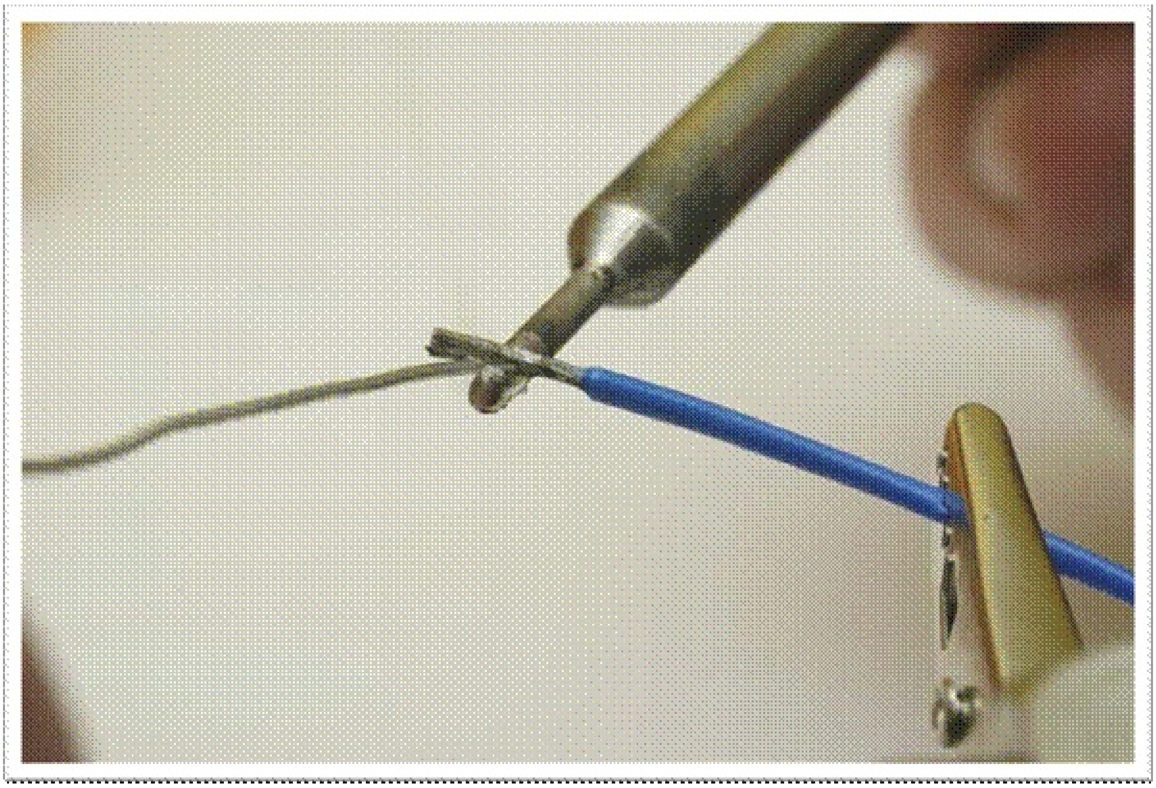
^^ How not to strip insulation off wire: some of the cores have also been cut – avoid doing this!



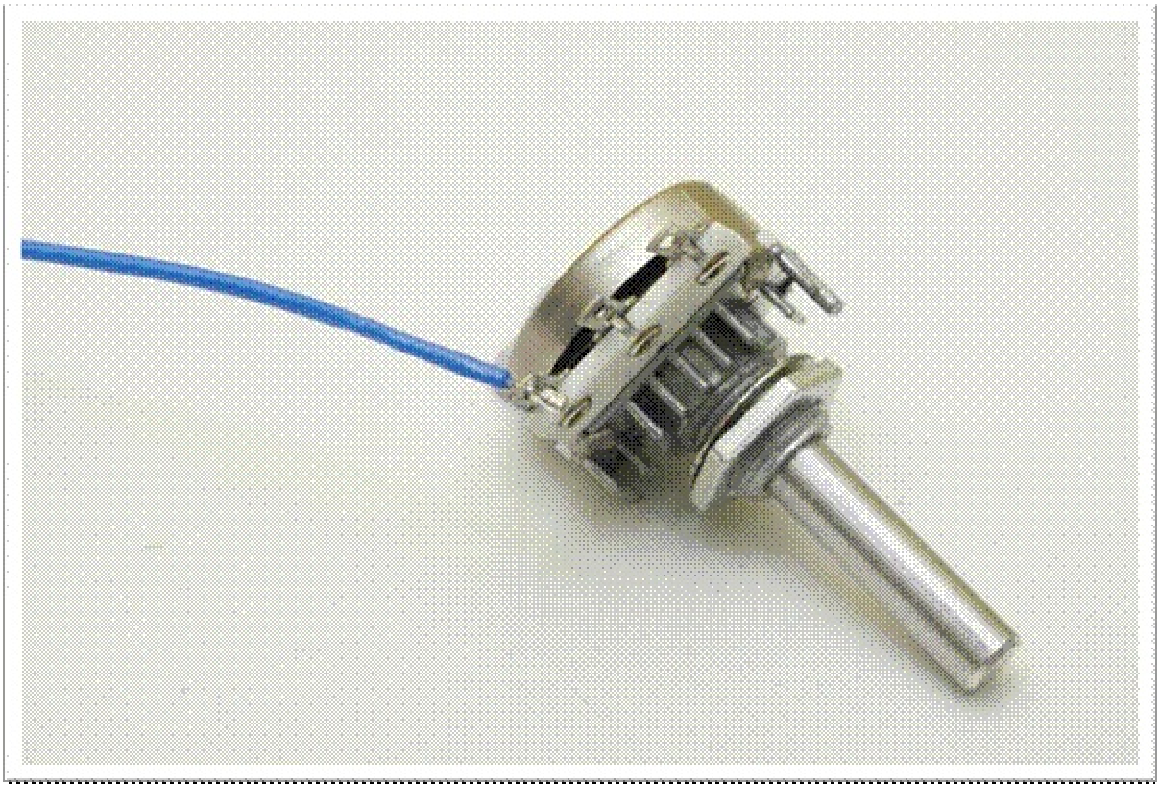
^^ Gripping a wire end in a "Helping Hand" croc clip can help with soldering.

After stripping a short length of insulation from the connecting wire, there are two ways to solder it to a component's solder tag. The first way is to "*tin" the stripped wire end to solidify it* - just heat it with the iron and melt a little solder on it, and let it cool. Poke the wire end through the solder tag, apply the hot iron to both parts and solder them together using a few millimetres of solder.

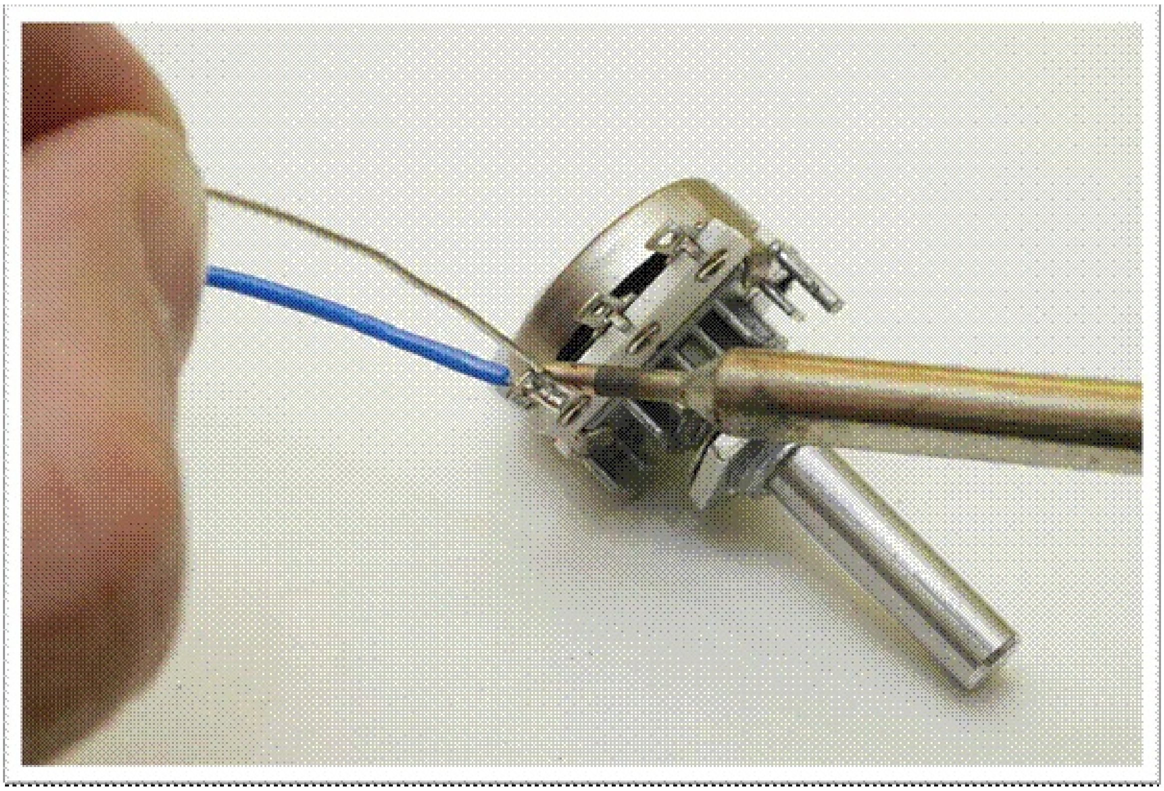
Although the assembly doesn't hold itself together so well during soldering (consider a Helping Hands jig if needed) this is quicker and easier to make and also easy to desolder again, and is perfectly adequate for most joints of this kind. The majority of commercial wire joints seem to be made this way.



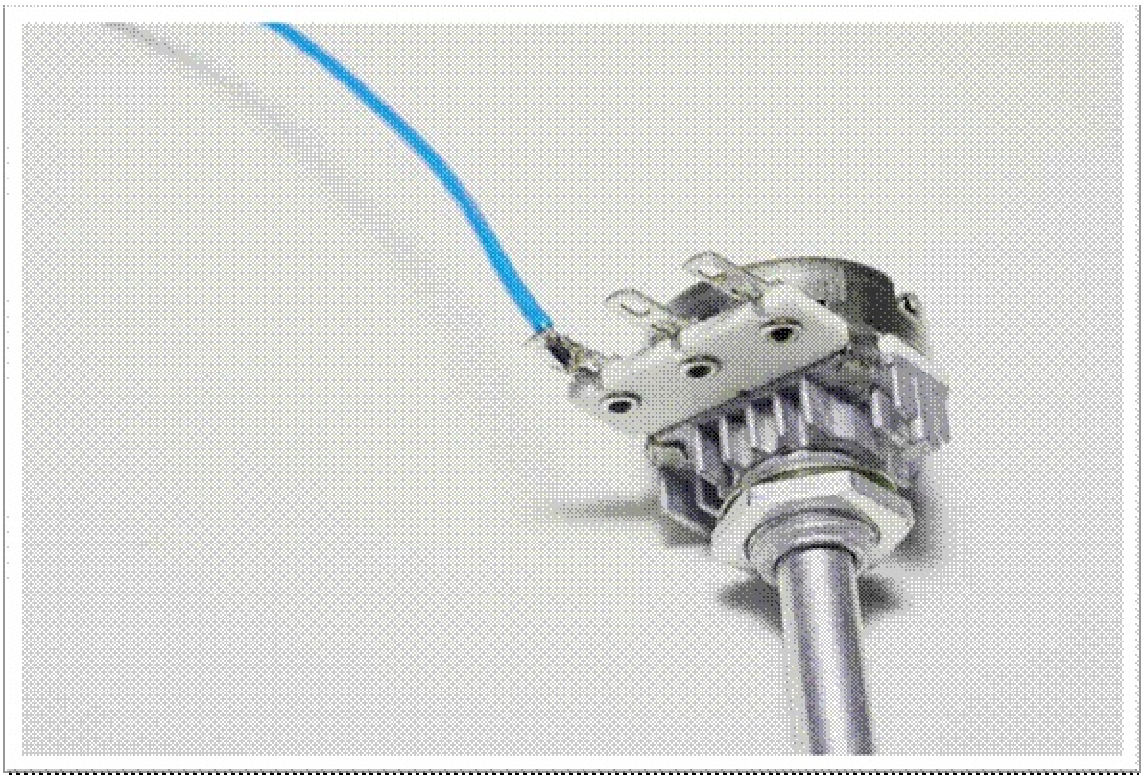
^^ *Apply a hot iron and solder, in order to "tin" the wire ends. This makes them into a solid.*



^^ *Then feed the tinned wire through the hole in the solder tag. Crop the wire with cutters if needed…*

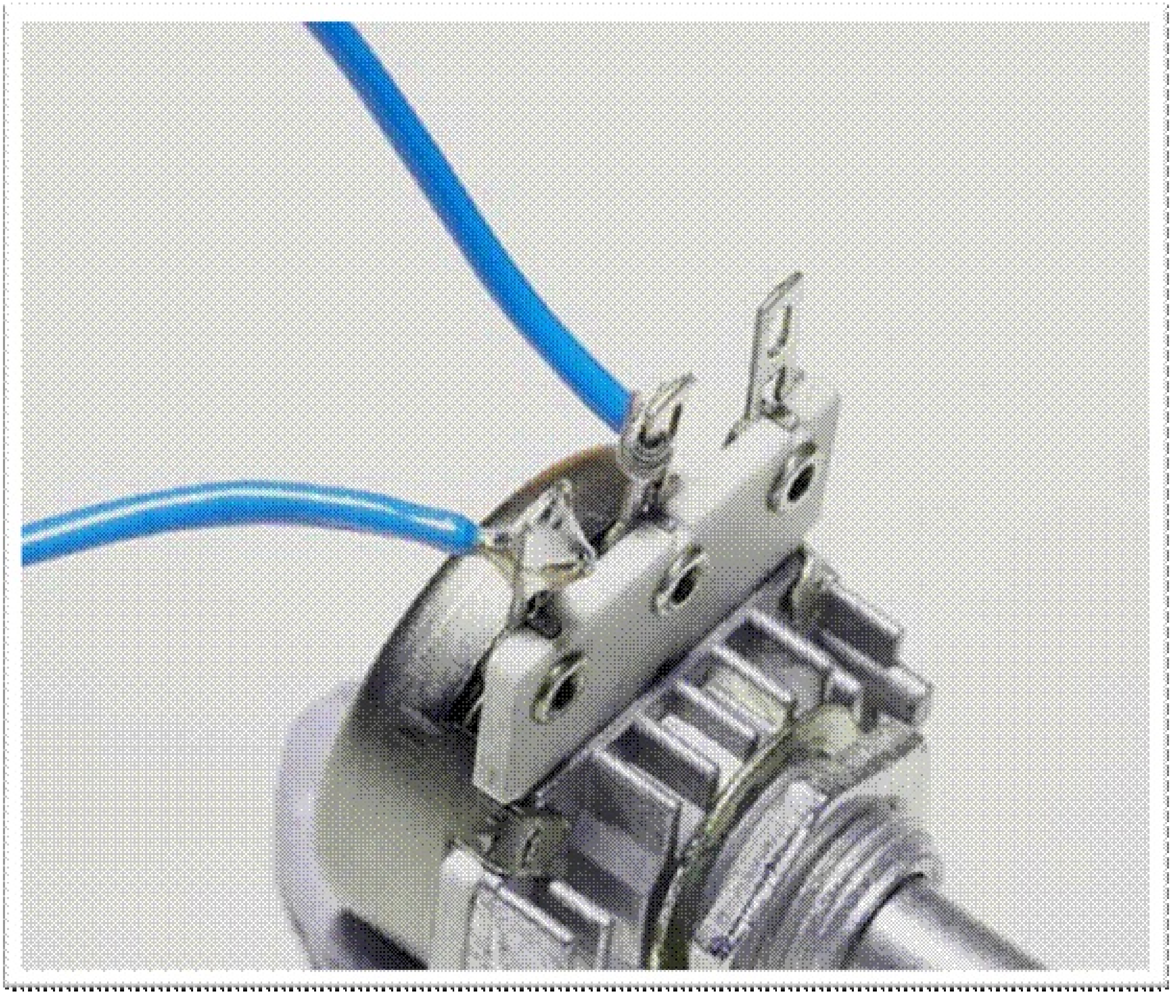


^^ … and apply the iron to heat the joint. As there's quite a lot of metal to heat, allow several seconds to heat it up and then simply solder the wire and solder tag together with a dab of solder wire.

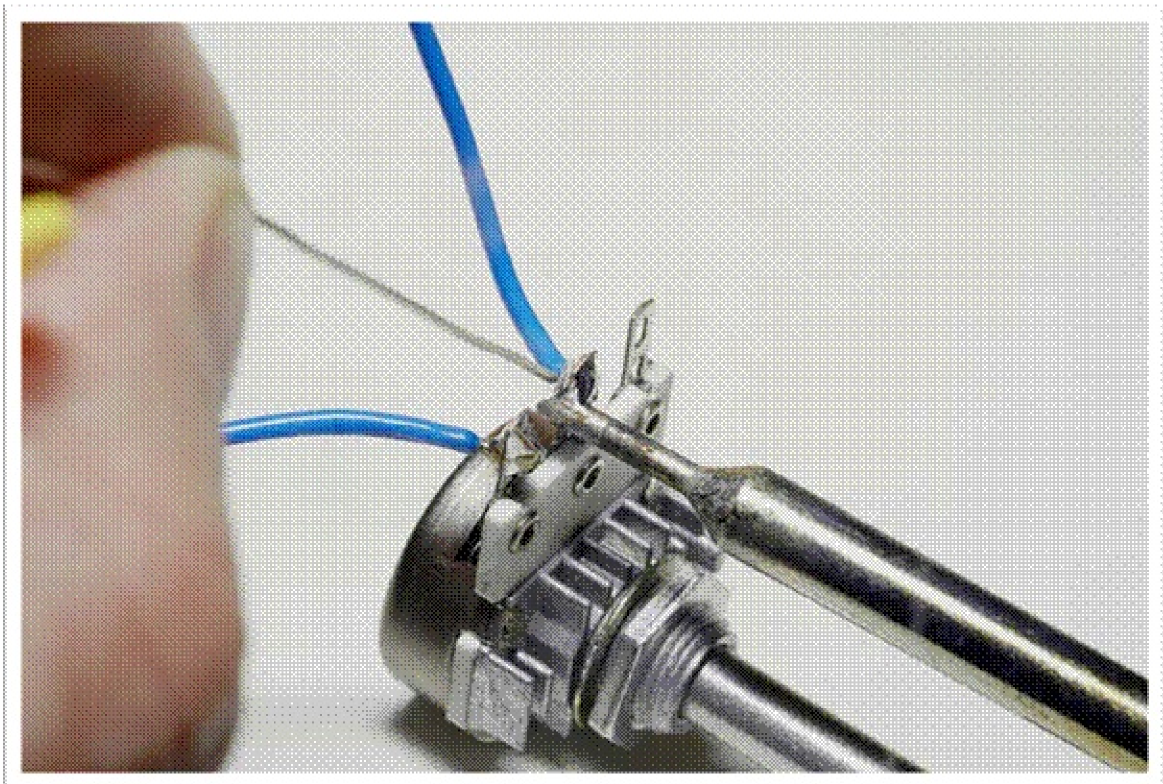


^^ The result is a perfectly satisfactory solder joint.

The second way is to loop the **untinned** wire through the tag a few turns and then solder it. This secures the wire during soldering, but it's messier to desolder if things go wrong (see later):



^^ The centre wire (potentiometer wiper terminal) has been wrapped around to secure it before soldering.

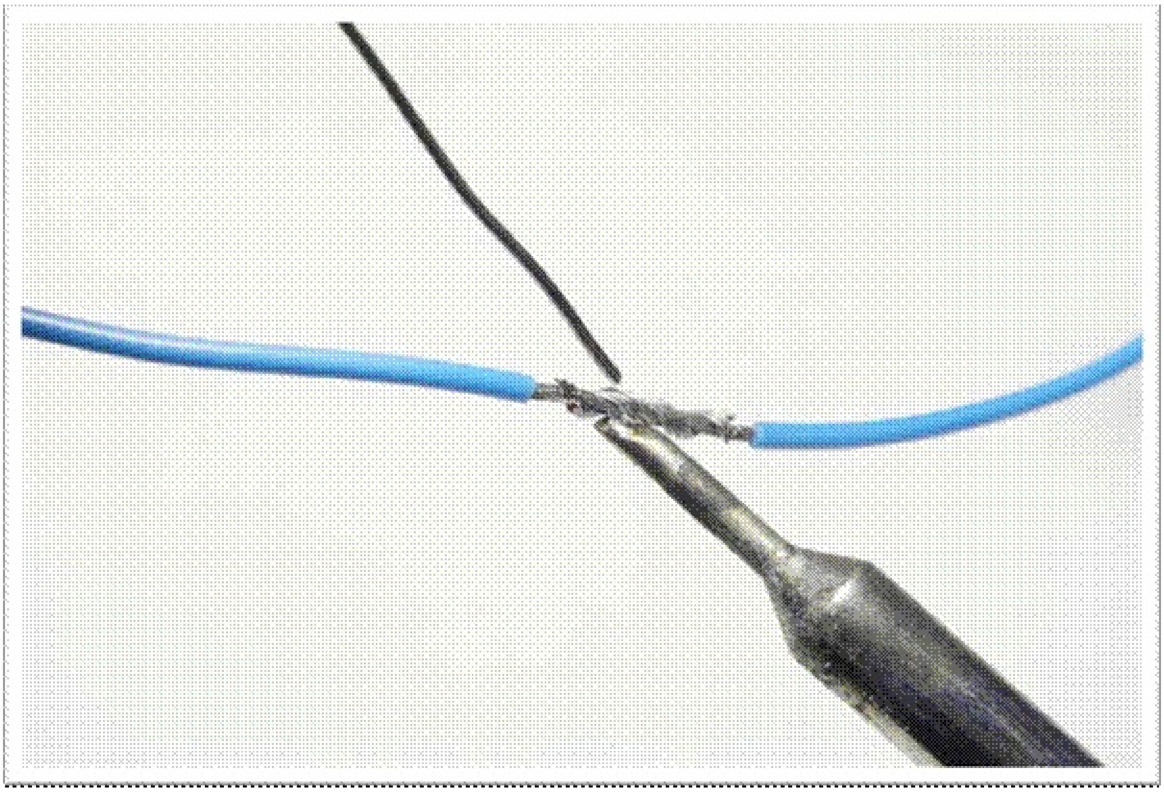


^^ Solder the joint in just the same way – heat it up and dab on some solder wire.

Much electronic equipment is connected or inter-wired this way and soldering everything together is a key stage in assembling any electronic project. I’ll explain some refinements you can try, later.

Wire joints

Soldering isn't always the best solution to some problems, for reasons that I explain in the next section called Fatigue and Breakage. However you can solder wires together to join them simply and cheaply, and next I show a classic wire joint of this kind, sometimes called a **Western Union** joint.

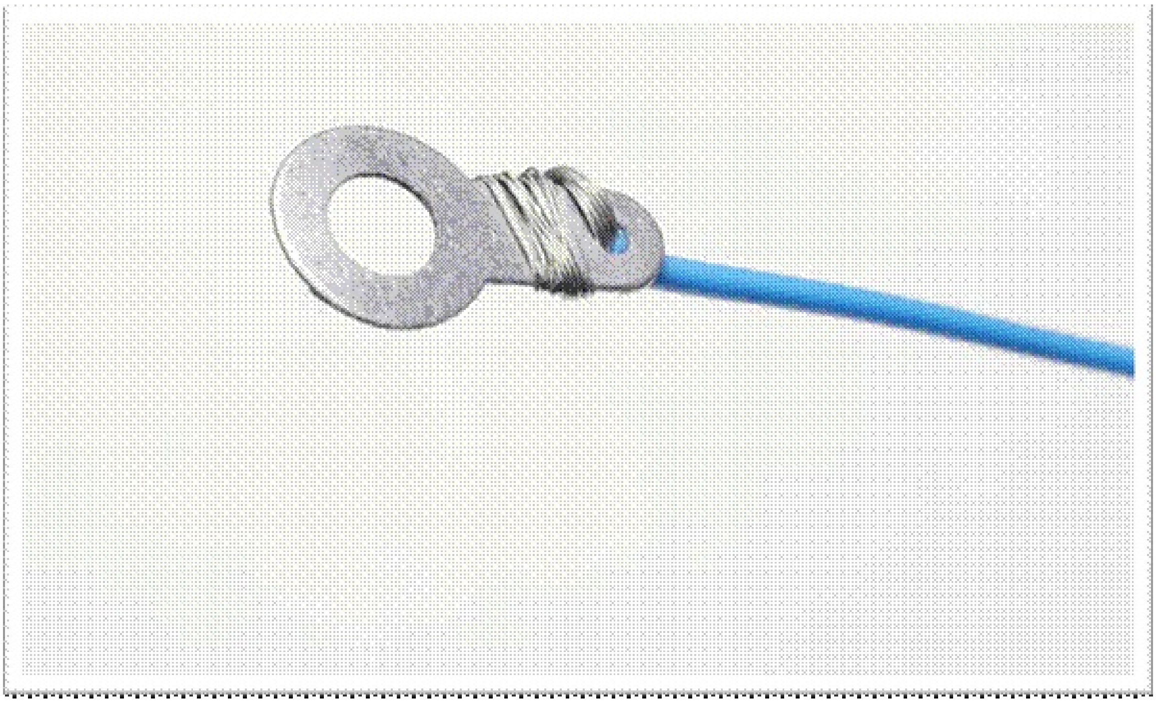


^^ *Soldering a Western Union wire joint.*

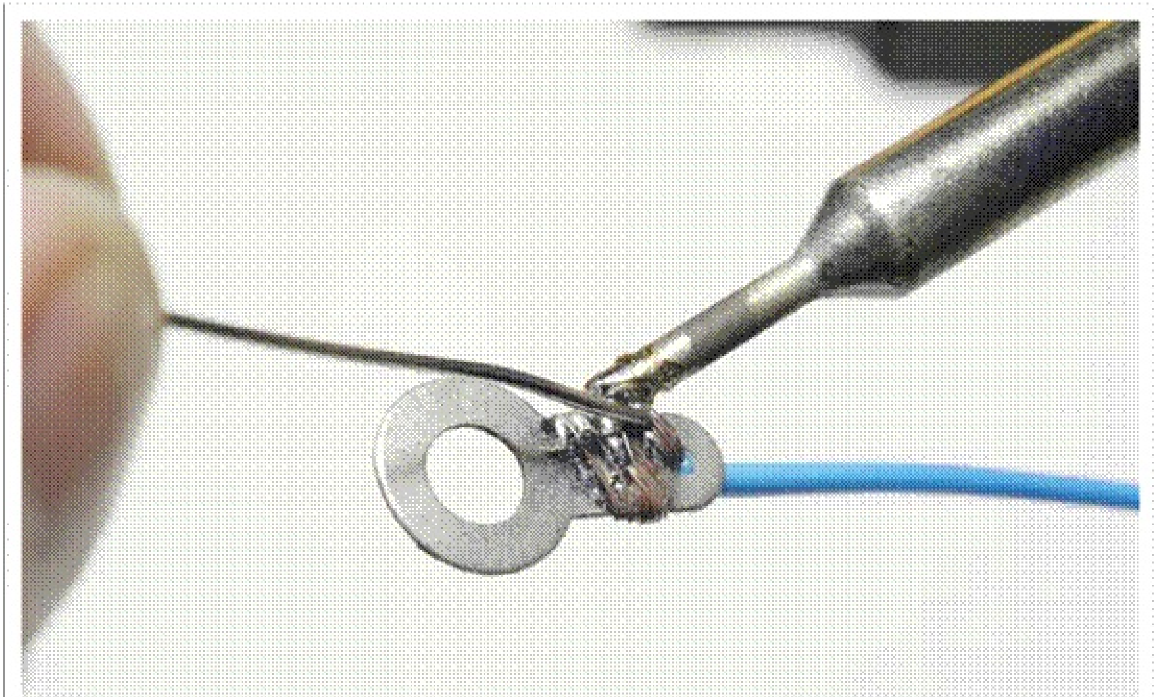
Strip the ends from each wire using wire strippers, and try not to cut any of the stranded cores or this will create a weakness. (Stray strands of wire can also be a hazard.) Then twist the wires securely together several times, ideally four or five. Apply a soldering iron to the exposed joint and dab on some solder until it flows fully over the joint, then remove the iron and allow the joint to cool.

The wire's plastic insulation may shrink back a little due to the heat, but try not to overheat it excessively. If you have the resources you can finish off by insulating the joint with some heatshrink tubing (slide it over a wire before you make the solder joint!). Otherwise use ordinary PVC tubing or insulation tape if you have any.

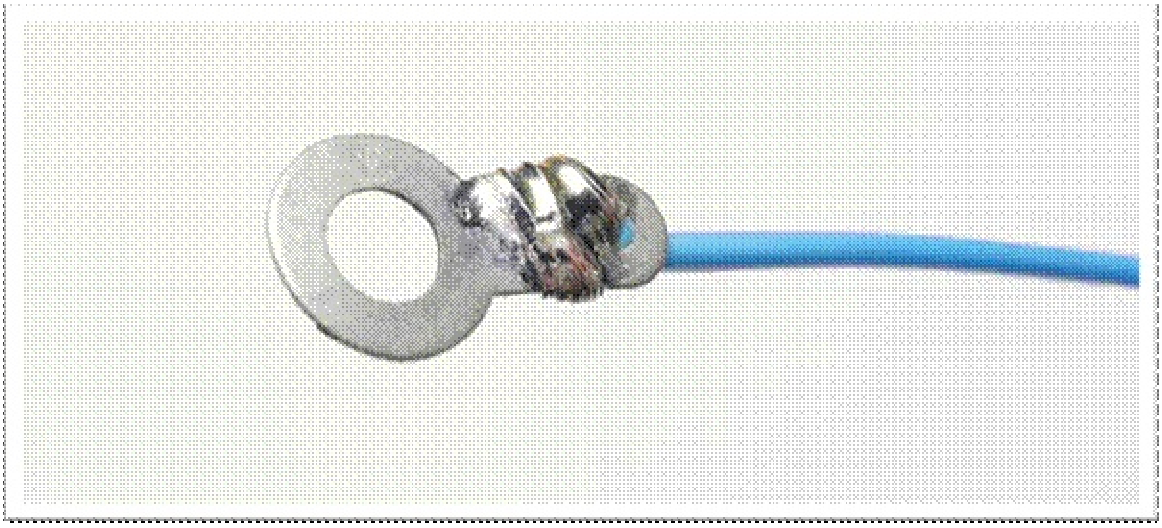
A solder tag can be soldered easily enough, and it's probably best to feed a stripped wire end through the tag and twist it over several times before soldering it, so it's held together when soldering.



^^ *A solder tag is soldered by wrapping a stripped wire end through the hole and round again, to secure it.*

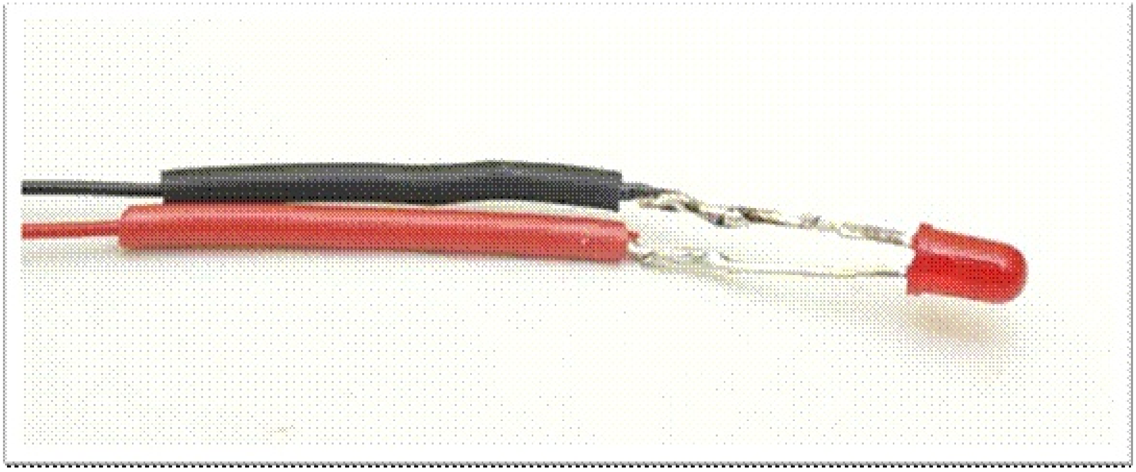


^^ *Apply plenty of heat and solder for a few seconds.*

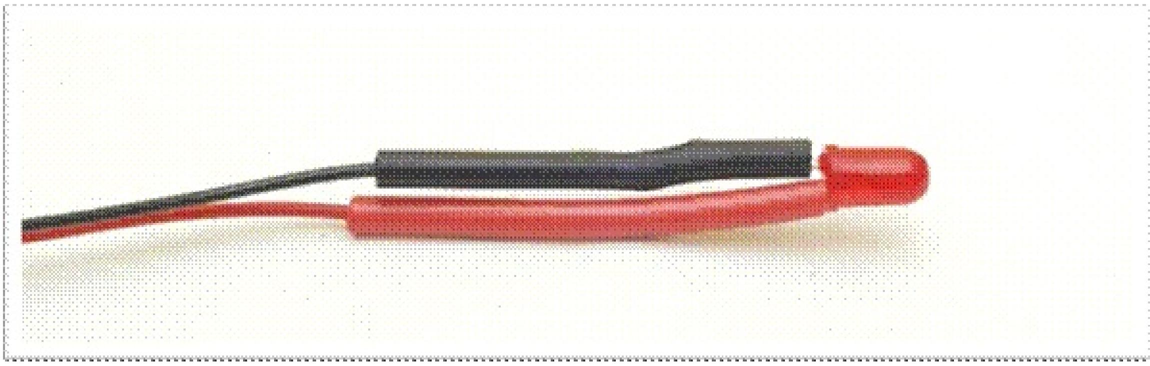


^^ *The completed solder tag*

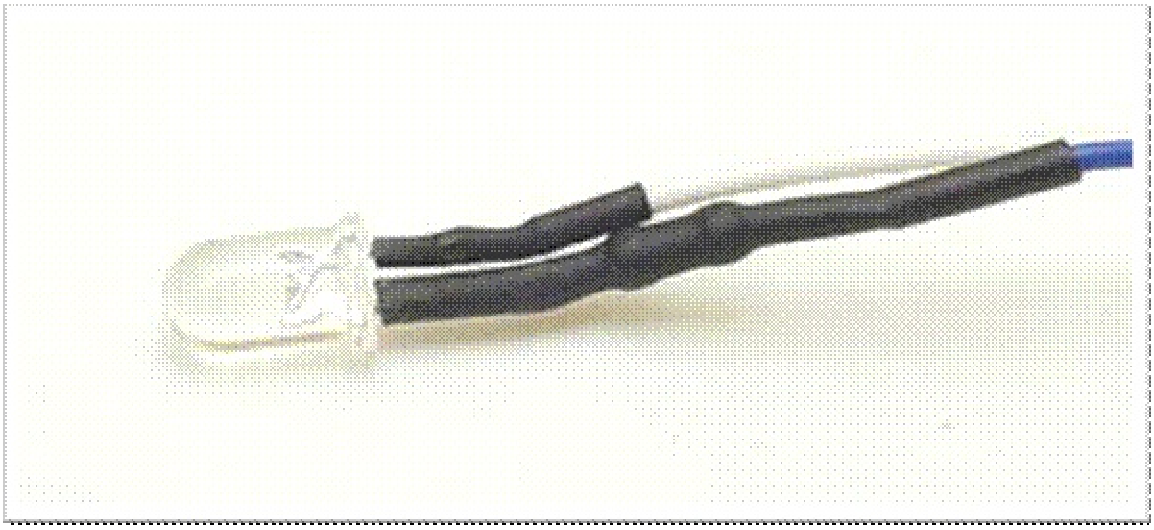
The next sequence show how the same basic principles of soldering wires are used to connect up a device such as a panel-mounting l.e.d.. A series resistor can be wrapped around and soldered directly to one of the l.e.d. solid wires, and then two multi-stranded connecting leads are soldered to the l.e.d. and resistor. It's best to use heatshrink tubing or PVC sleeve to insulate the solder joints and prevent short circuits afterwards.



^^ *Multi-stranded wires can be soldered to the solid leads of an l.e.d.: insulate them afterwards. Different coloured wires identify the polarity of anode and cathode.*

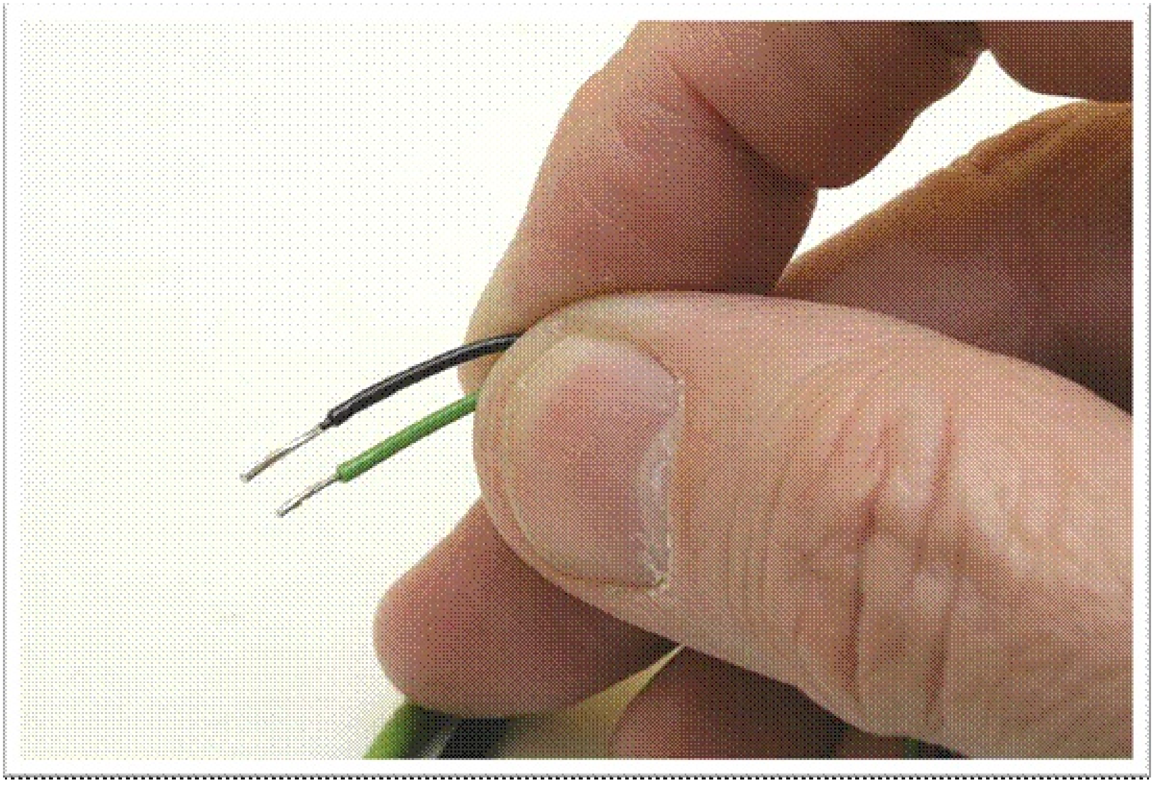


^^ *PVC sleeving or heatshrink is needed to prevent short circuits.*

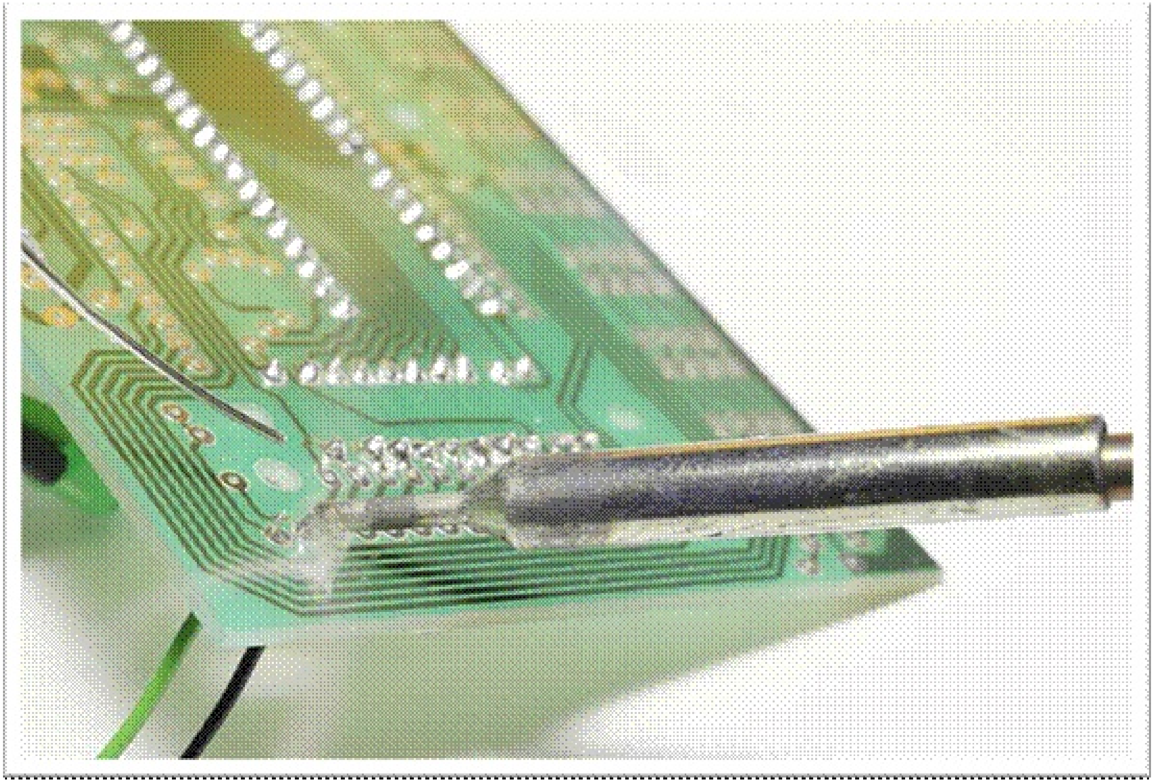


^^ A commercial l.e.d.– the series resistor can be made out in the sleeving.

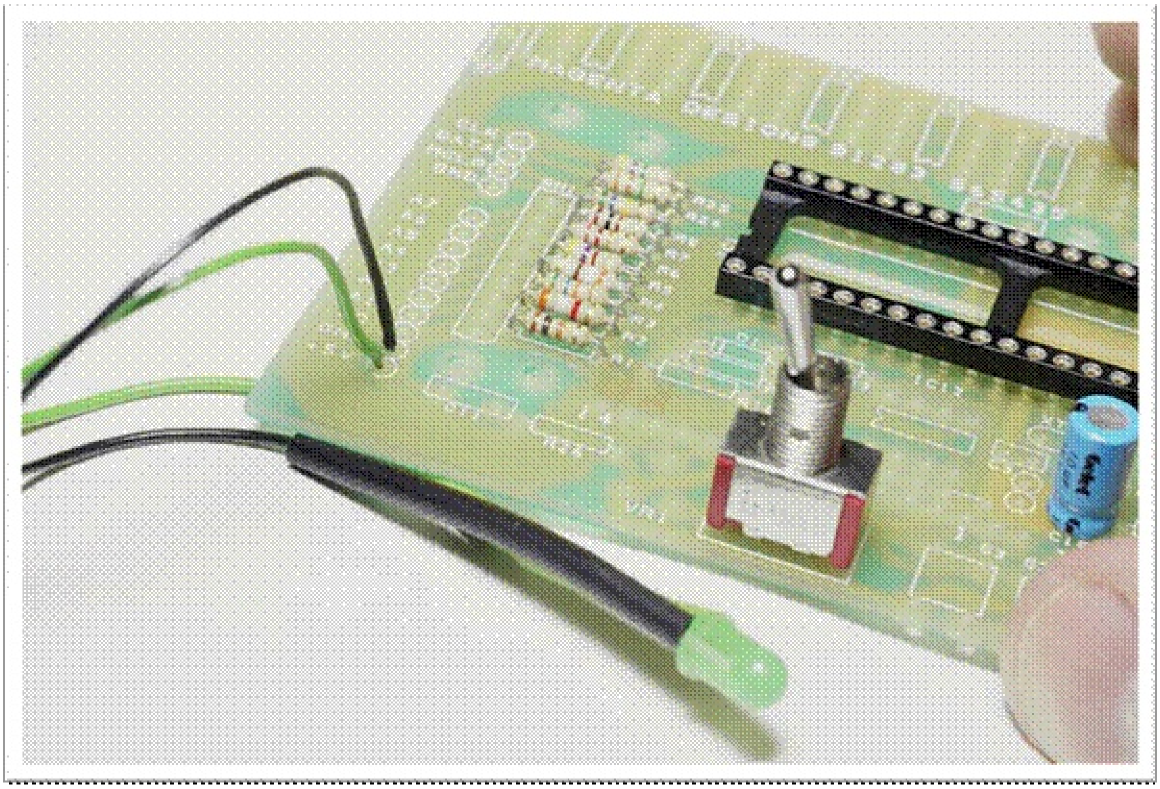
Wires can also be soldered directly to printed circuit boards by stripping and tinning the ends, provided they fit through the holes in the p.c.b. It's a very common and cheap way of hooking up a board using "flying leads" and you'll see this all the time in consumer electronic equipment. For convenience so-called "solder pins" can be used, onto which flying leads may be soldered from the component-side instead.



^^ A set of l.e.d.s connecting wires, stripped, tinned and ready to be soldered to the p.c.b.



^^ Solder the two "flying leads" to the copper pads in the usual way. Hopefully the holes are big enough for the wires!



^^ Connecting an l.e.d. to a circuit board with flying leads.

Wires can also be attached to the underside (solder-side) of circuit boards, tacking them onto existing solder joints by re-melting them and absorbing the tinned wire end into it ("reflow soldering" – see later). This is a cheap and cheerful, semi-reliable way of rigging wires to a circuit board, and it's used all the time in imported consumer electronics.

Tidying up

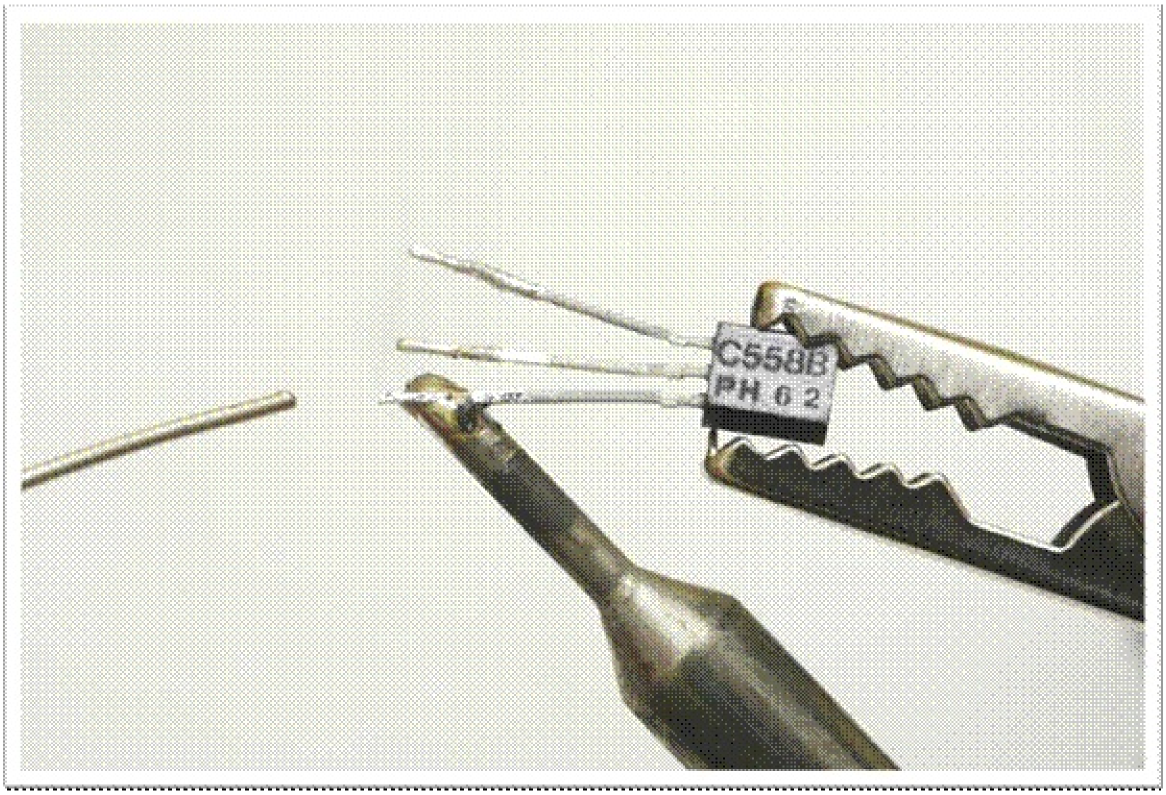
I'll leave it to readers to decide whether they should cut off excess wire before or after soldering. After the soldering is complete, I prefer to tidy up the joint by snipping any excess wire from the joint using a pair of "end cutters" shown earlier. These expensive hand tools have specially angled blades that snip the joint neatly down to the top of the solder joint. Ordinary side cutters will do fine.

It's worth taking time out to inspect the work closely, looking for any missing solder joints, whiskers of solder or swarf shorting out any solder pads, and all such potential problem areas should be dealt with prior to testing the board. Faultfinding goes beyond the scope of this guide, but it's true to say that almost always, any problems noticed after powering up the circuit are due to soldering faults or wrong components being used.

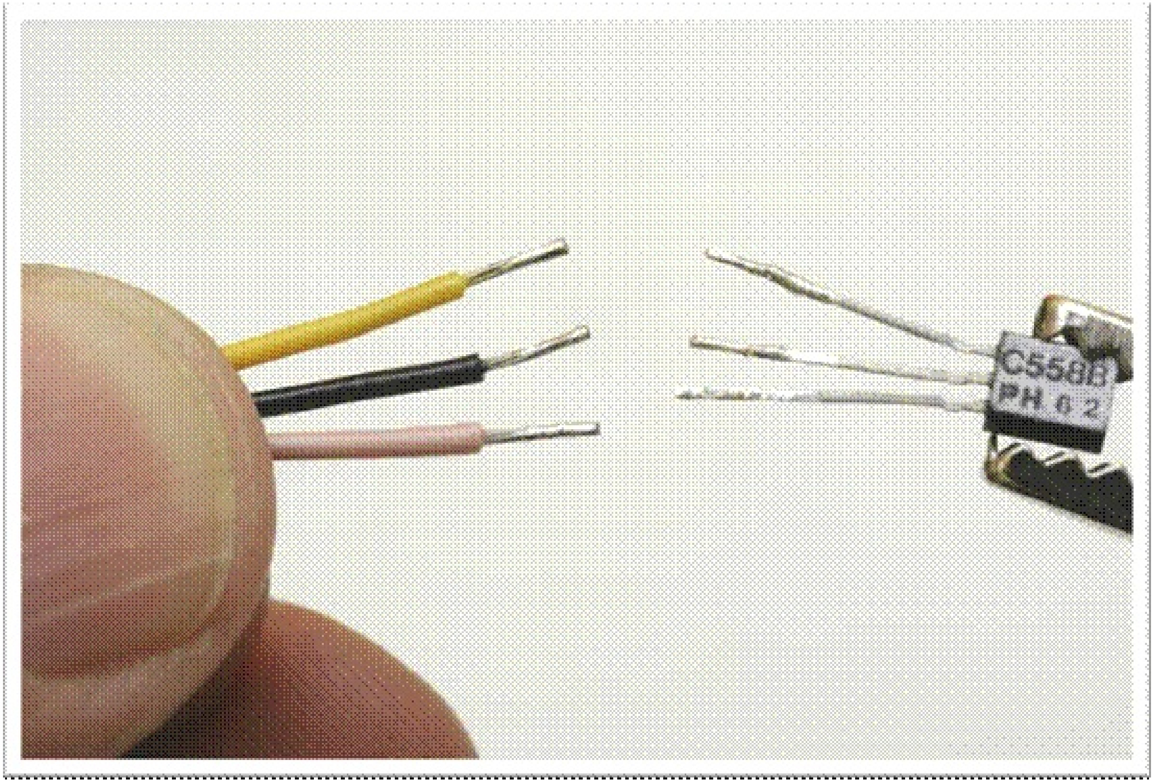
Reflow technique

Another technique often used is “reflow” soldering. This is used to “tack” devices or wires together, especially if very small, sensitive or fiddly parts are involved. There might be no room to make a “proper” sturdy joint, or it might just not be necessary to have any mechanical strength in the joint, especially if tiny parts are used.

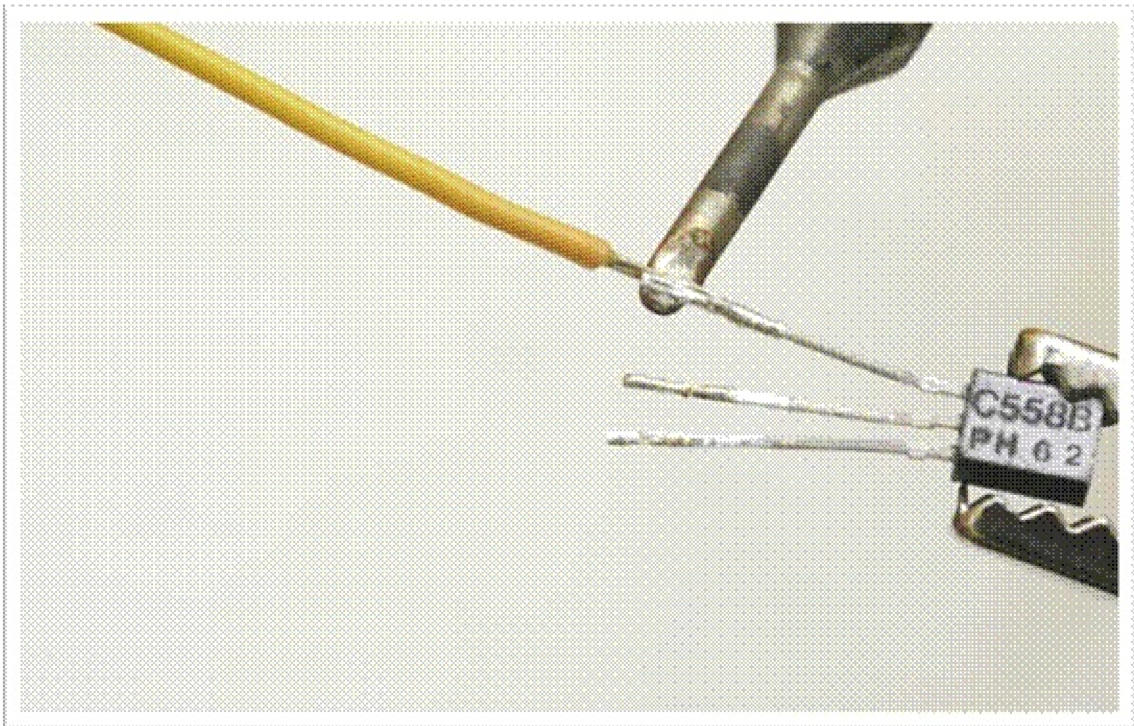
As an example, imagine a small temperature sensor (I used a transistor) for use in a thermometer project. It could be quite tricky to solder flying leads onto the sensor’s leadouts, so a good approach is to tin both the flying leads and the sensor’s leads, and then simply touch them together and re-melt the solder with the iron. There’s no need to add any more solder, because the solder that’s already there will re-melt and the joint will be made. Sometimes this is called a butt joint.



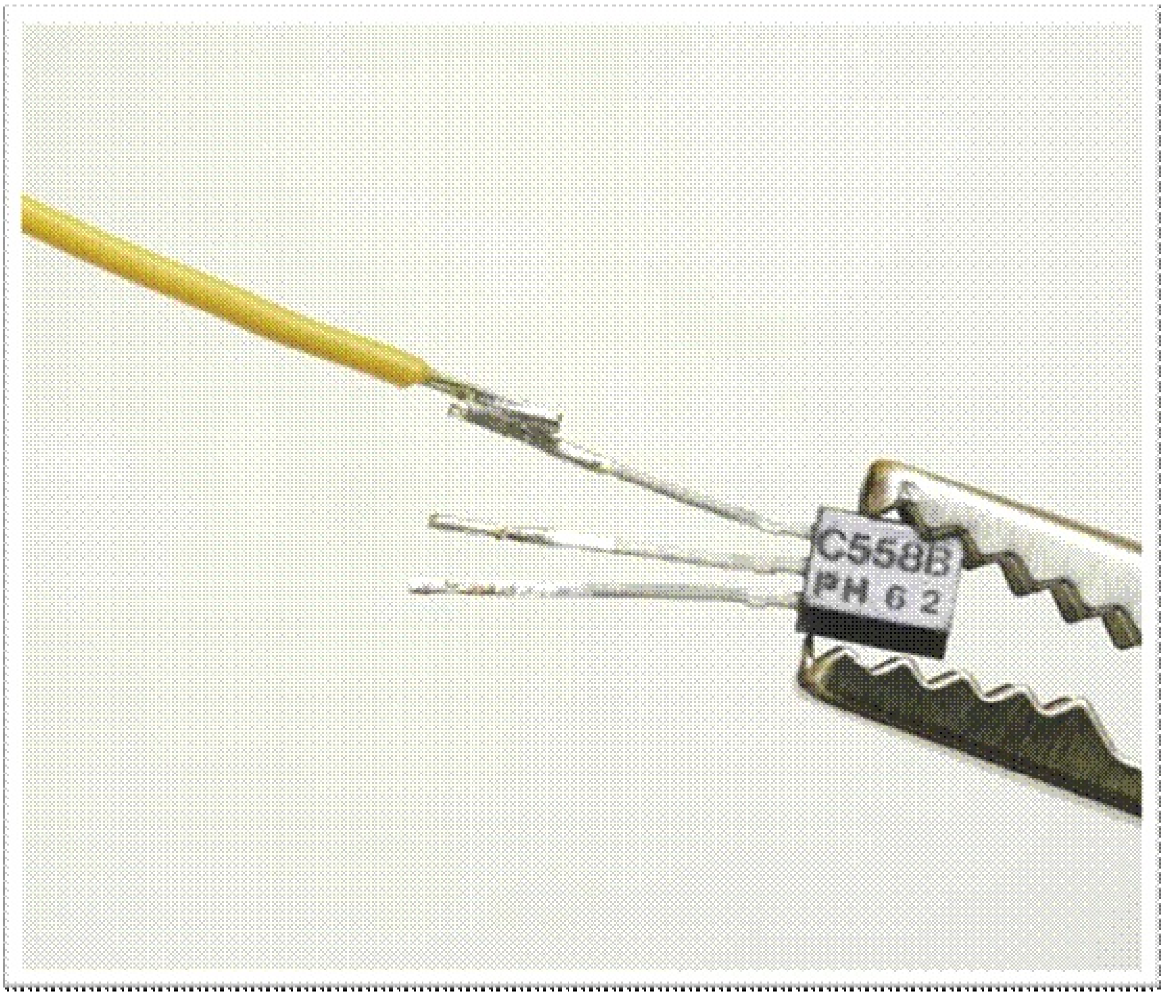
^^ *The leads of this sensor (transistor) have been tinned, ready for flying leads to be tacked onto them with a reflow method. A Helping Hands jig might help!*



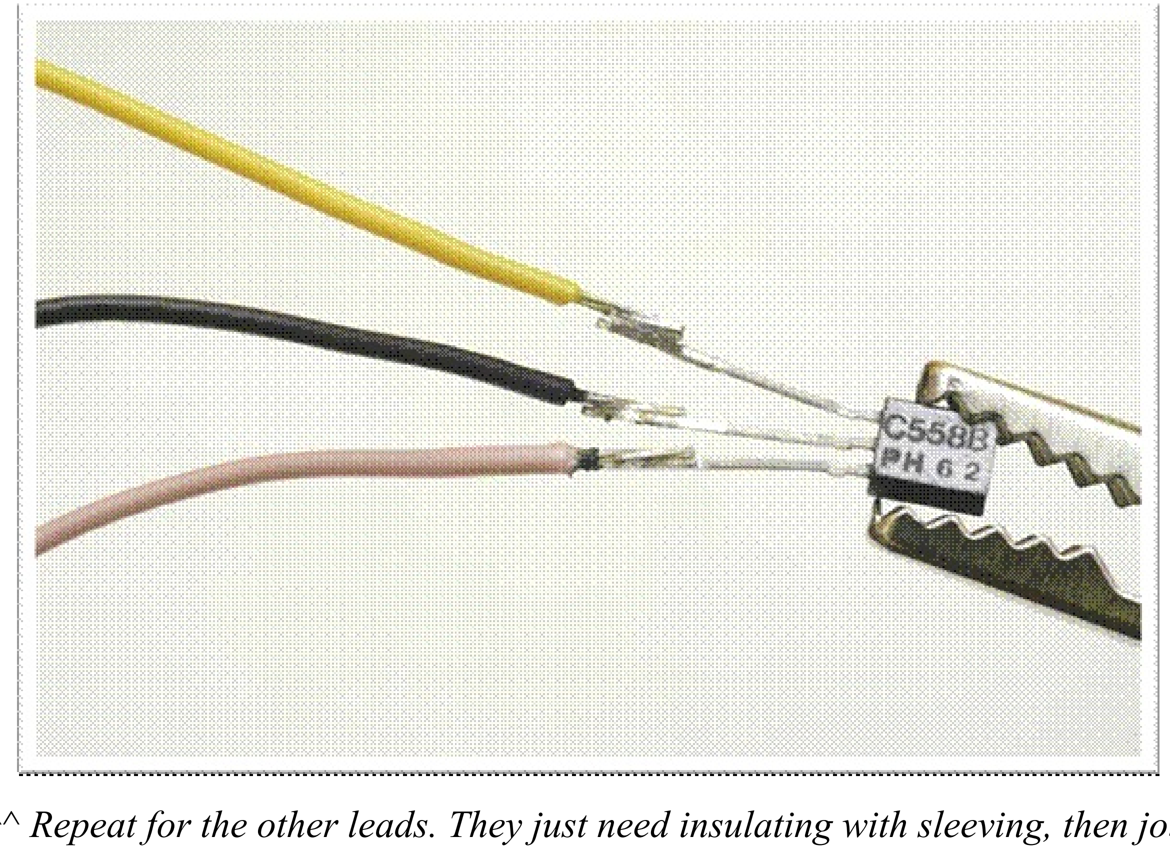
^^ *The three flying leads stripped, tinned and ready to be reflow-soldered onto the device.*



^^ *To reflow solder them, simply hold the two leads together while re-melting the solder with the iron.*



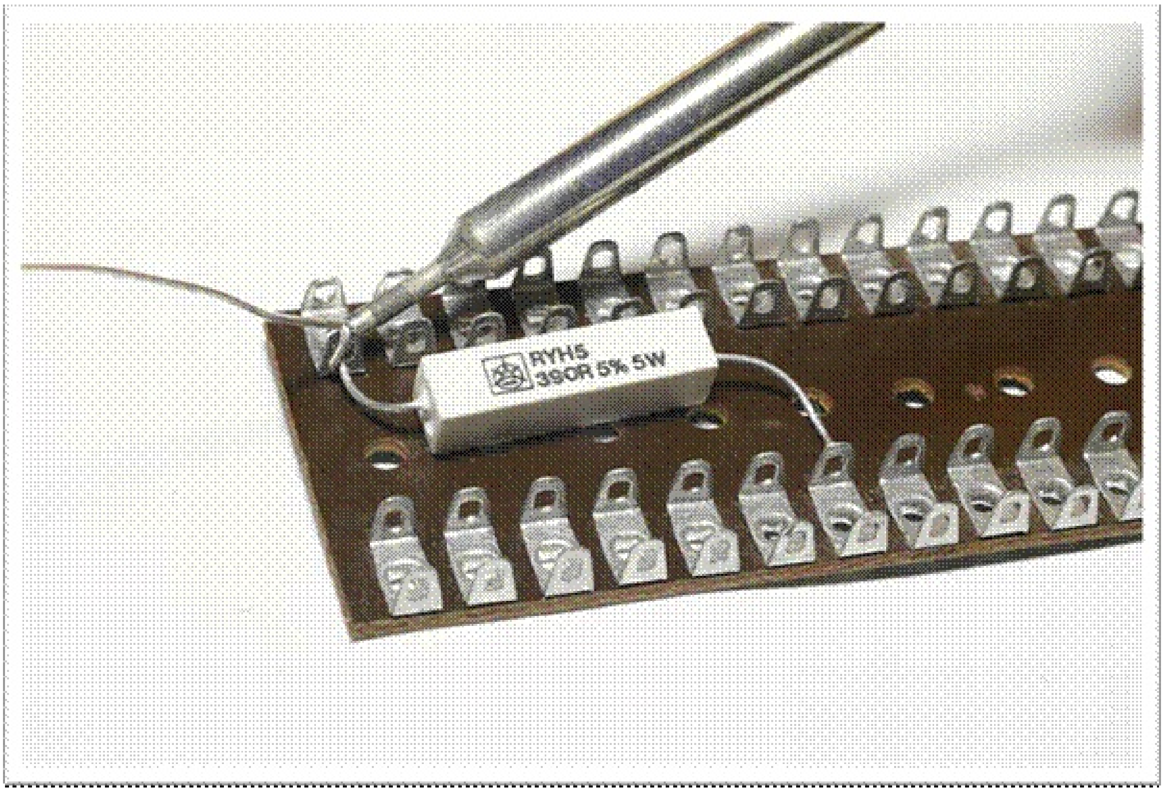
^^ Remove the iron and let the solder cool. The wire is tacked on.



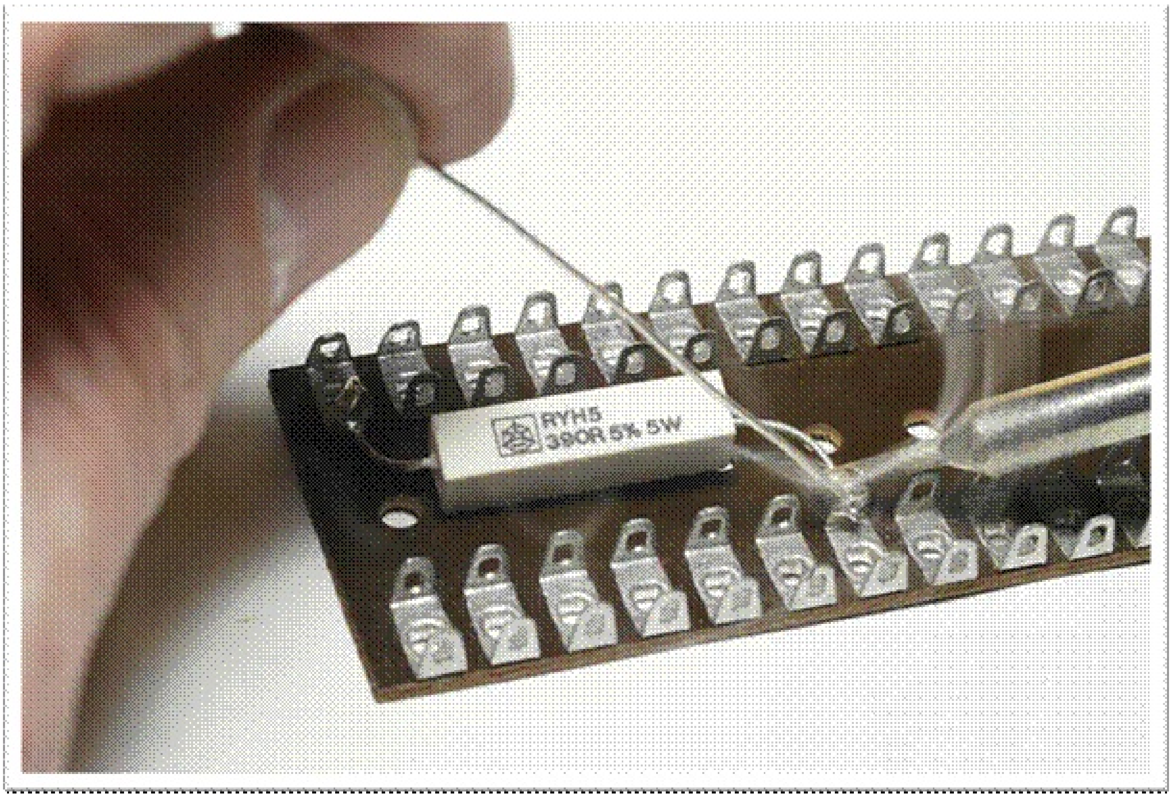
^^ Repeat for the other leads. They just need insulating with sleeving, then job done!

Depicted next is a typical “tag strip”, an insulated panel with metal solder tags used for making sundry connections. (Entire TVs and radios used to be hand-built with them, in

the early-mid 20th Century!) The principles of soldering are exactly the same, but more time is needed when applying the soldering iron because more metal is present, which needs more heat. You'll need more solder for bigger joints like these, so larger diameter solder makes a quicker job of it. Consider adding more flux (see earlier) to see if it helps.



^^ Wrap wires through the terminals and arrange everything neatly, then solder as normal.



^^ Don't be afraid to apply more heat with larger assemblies like these: they contain more metal than, say, an ordinary p.c.b so allow more time for the solder to flow over

everything properly.

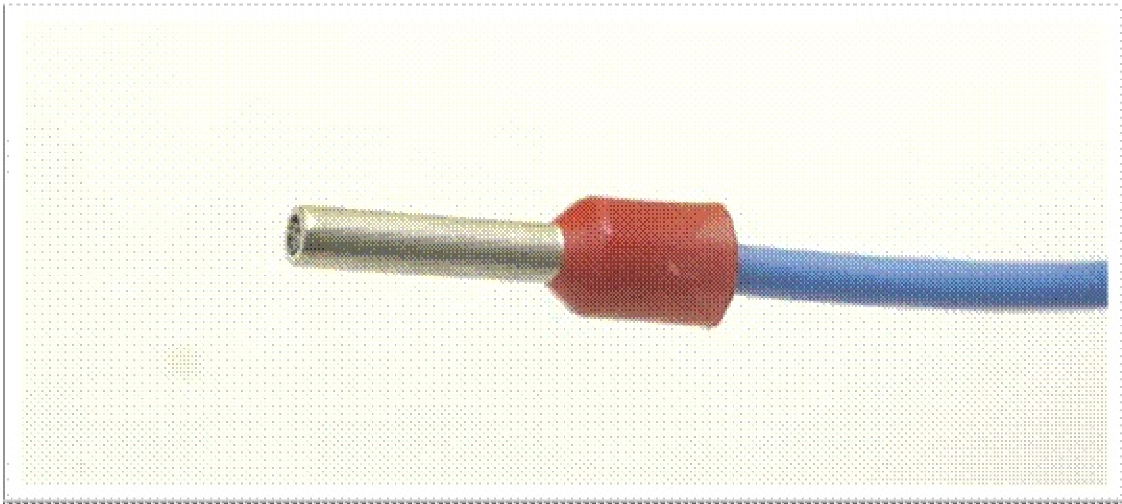
Fatigue & Breakage

Earlier I explained how multi-stranded hookup wire is flexible, which also makes it vibration proof – that's why a car's electrics are full of multi-stranded wiring, and test equipment probes use ultra-flexible multi-stranded wire for the same reason. Solid-core wire can be bent and will stay in shape (called "plate wiring") but if it's repeatedly bent or vibrated then it may eventually break somewhere due to fatigue.

The same is true of wires that have been soldered or tinned. No longer is the wire 100% multi-cored and flexible – instead it's been turned into a *single core wire* at the point where it's been soldered. This is potentially a weak spot and could eventually fracture due to fatigue, if subjected to continued vibration (e.g. in a car engine bay or in motorised equipment).

In a lot of equipment problems can be avoided by adding *strain reliefs* of some sort, to stop the wire being flexed where it's been soldered. Heatshrink tubing, or a dab of hot-melt glue, are ways of taking the pressure off the joint and ensuring soldered wires won't snap off due to vibration.

One of the reasons that higher-quality equipment and cars etc. use crimp terminals and connectors is that crimped (as opposed to soldered) connections retain all the flexibility of multi-core stranded wire from end to end, avoiding problems of wires breaking off. A *ferrule* is a very neat way of tidying wire ends and preventing stray strands of wire doing damage. Ferrules can be used to connect wires into screw terminal blocks etc. Simply clamp the terminal block down onto it and the screw will grip the ferrule.



^^ *Instead of soldering them, wires can be terminated with ferrules prior to fitting to e.g. screw terminal blocks. This makes them vibration-proof and also avoids any problem of stray wires poking out.*

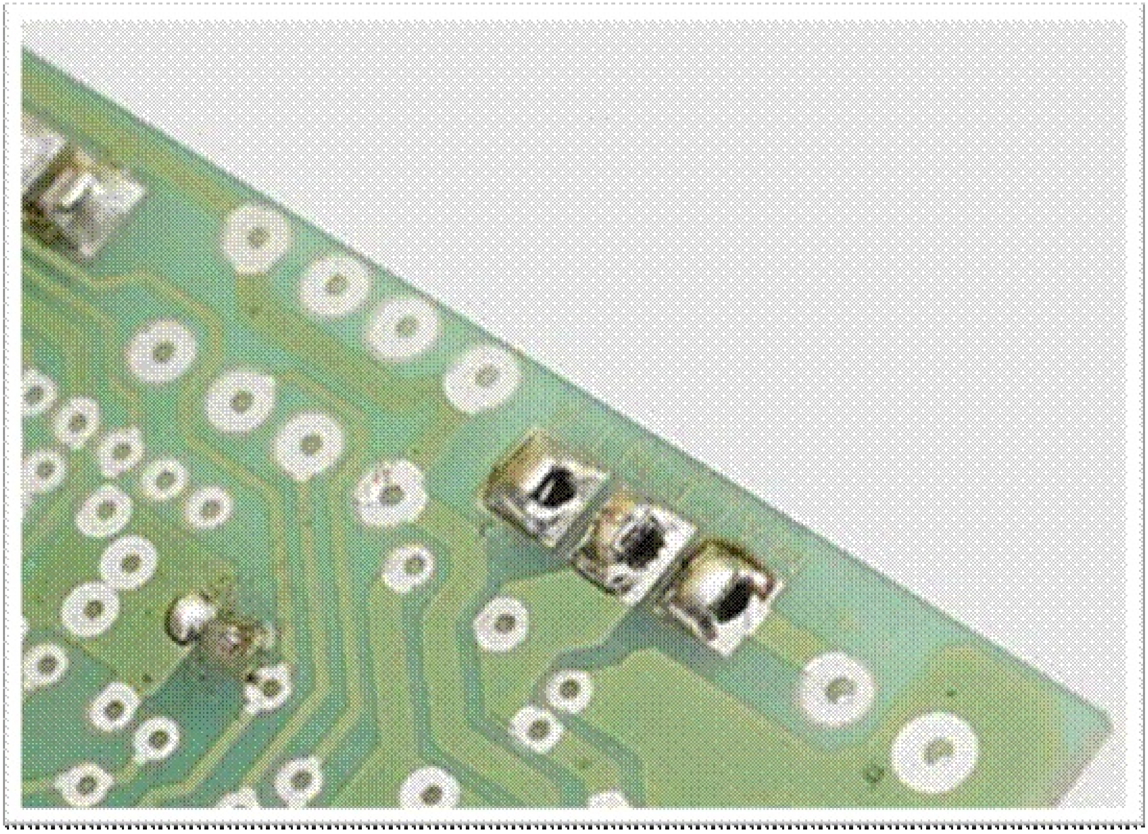
Faults & Desoldering techniques

By putting into practice the guidelines in my *Basic Soldering Guide* practice, there’s no reason at all why you should not obtain perfect results and eliminate any potential problems. Hopefully the information gives you plenty of guidance to tackle various soldering projects with confidence. There’s no substitute for getting some hands-on experience though, so I’d repeat the advice to try assembling a simple high quality electronic kit or two, such as those produced by Velleman and see how you get on. Powering up your first project successfully is a great thrill as every electronics hobbyist knows.

^^ *Popular desoldering products, a pump and various widths of desolder braid.*

Let’s now look at reversing the soldering procedure – what to do if things go wrong, or maybe you have to repair a circuit by replacing a faulty component.

A solder joint which is badly made is likely to be electrically “noisy”, unreliable and will probably worsen over time. Expansion and contraction of the joint due to heating and cooling can also throw up intermittent problems later down the line. The joint may look OK but underneath it may have a poor electrical connection, or could work initially and then cause the equipment to fail at a later date! These intermittent problems can be maddening to fix. TV repair technicians have an uncanny ability to go straight to a faulty solder joint because they see the same problem all the time, especially on equipment that has a “reputation”.



^^ *These dry or grey/ gray joints were caused by dirty parts, poor heating and inadequate solder coverage*

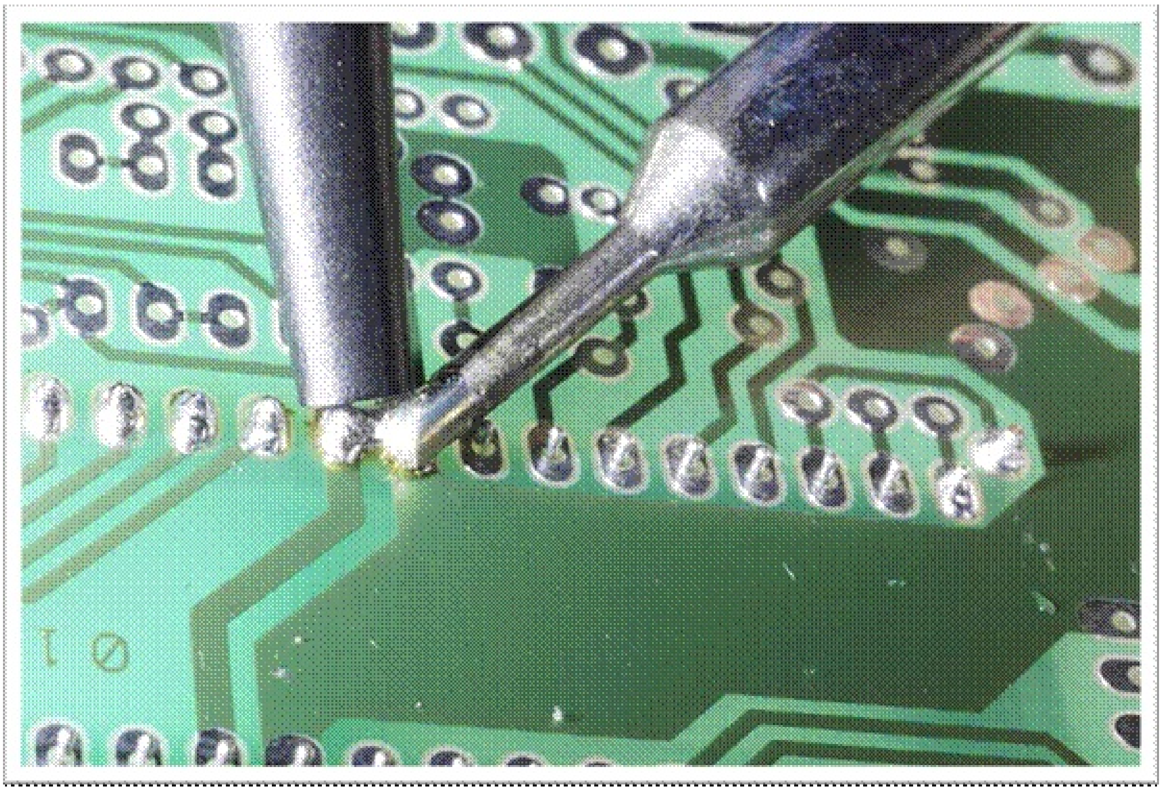
A solder joint that's poorly formed is called a “dry joint” or “cold joint” or a “grey/ gray” joint. Usually it results from inadequate heating, dirt or grease preventing the solder from melting onto the parts properly, and is often noticeable because the solder tends not to wet the surface properly. Instead it forms beads or globules. Alternatively, if it seems to take a very long time for the solder to wet the joint, that's another sign of contamination and that the joint may be a dry one, or the material is incompatible anyway. A matt, crystalline appearance instead of a shiny joint points to inadequate heating: the solder cooled down far too quickly and didn't flow properly.

Whether you want to replace a faulty component or fix a dry or poor-quality solder joint, it's usually necessary to remove the troublesome solder and then re-solder it afresh. Naturally, there are tools and techniques that make the job easy. It's very bad practice to simply re-melt the joint and then lash out with the board, whiplash style, hoping that the molten solder will be flicked off the board.

The usual way of removing solder from a joint is to use a *desoldering pump*. These work like a small spring-loaded bicycle pump, only in reverse! A plunger is pressed down until it locks into position. It's released by pressing a button which sucks air back through a pointed nozzle, carrying any molten solder with it. It may take one or two attempts to clean up a joint this way, but a small desoldering pump is an invaluable tool especially for p.c.b. work and they are widely available now.

^^ *A hobby desoldering pump primed for use*

Desoldering pumps often have a heatproof P.T.F.E. nozzle which may need replacing occasionally. Each time the button is pressed, a plunger clears the nozzle but sometimes solder particles and swarf will be ejected in the process; when you prime the pump, point the nozzle into a small pot or old aerosol top to catch any debris. Remove the spout and clean out the pump from time to time.



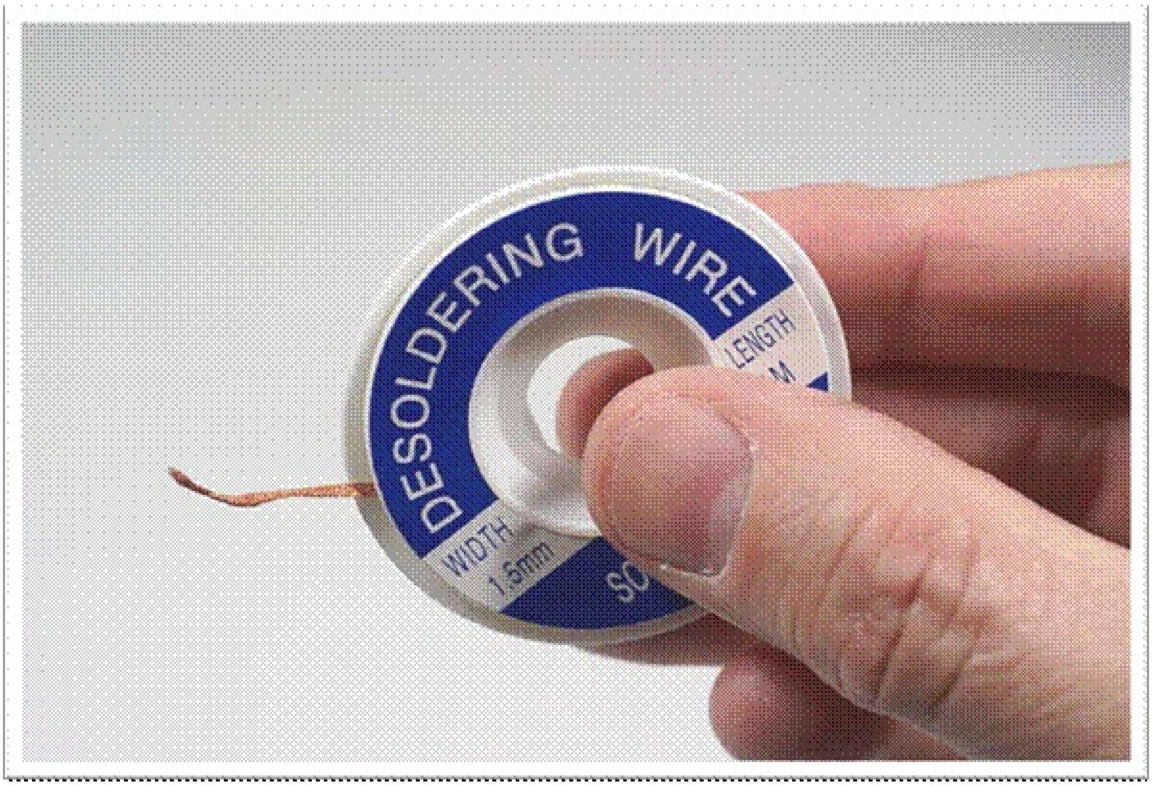
^^ *Suck up molten solder using a desoldering pump*

With very stubborn joints where the last traces of molten solder just can't be shifted,

it sometimes helps to actually *add* more solder and then desolder the whole lot again with a pump.

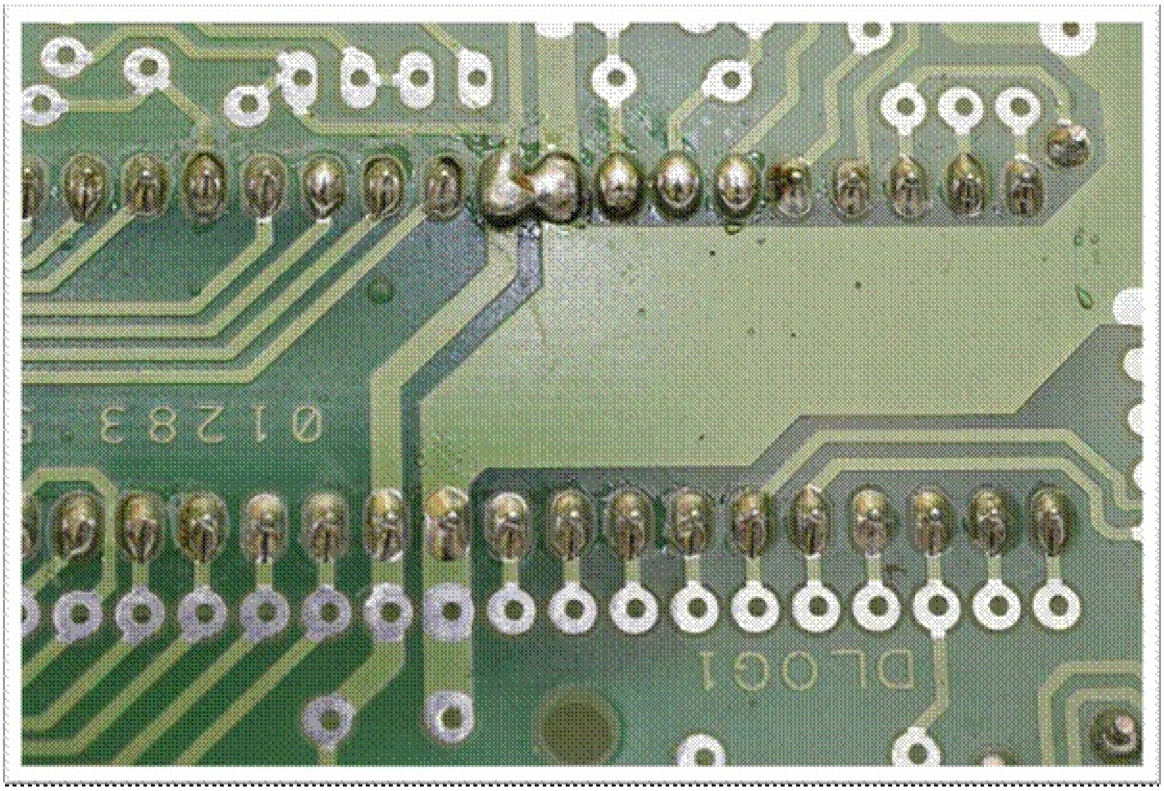
Desolder Braid

An alternative to a pump is to use *desoldering braid* which arrives in small dispenser reels. It’s a flux-impregnated fine copper braid which is applied to the molten joint, and the solder is then drawn up into the wick by capillary action. It’s remarkably effective and for certain tasks, it can be more thorough than a pump. I recommend that a small reel is bought (start with 1.5mm width) for the toolbox, to tackle larger or difficult joints which would take several attempts with a pump.

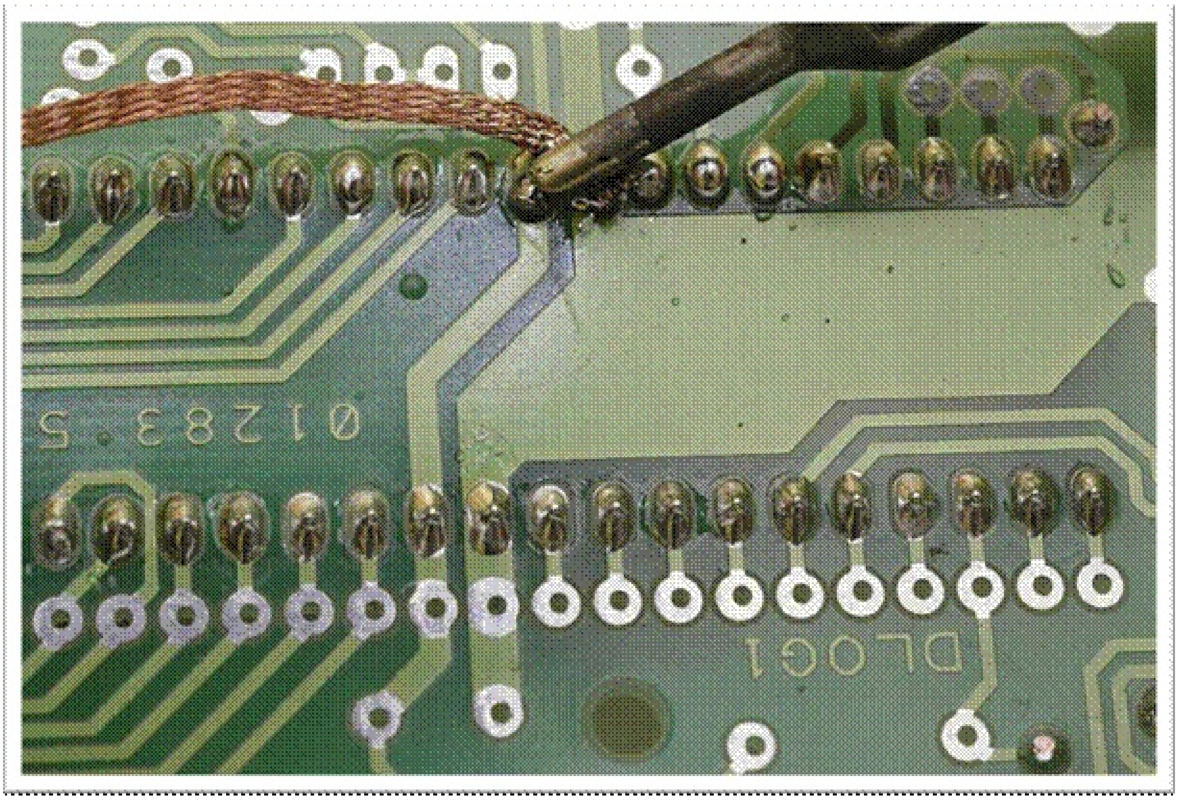


^^ Desolder braid is also handy and can sometimes be more effective than a desolder pump. It comes in various widths to suit the scale of work being tackled.

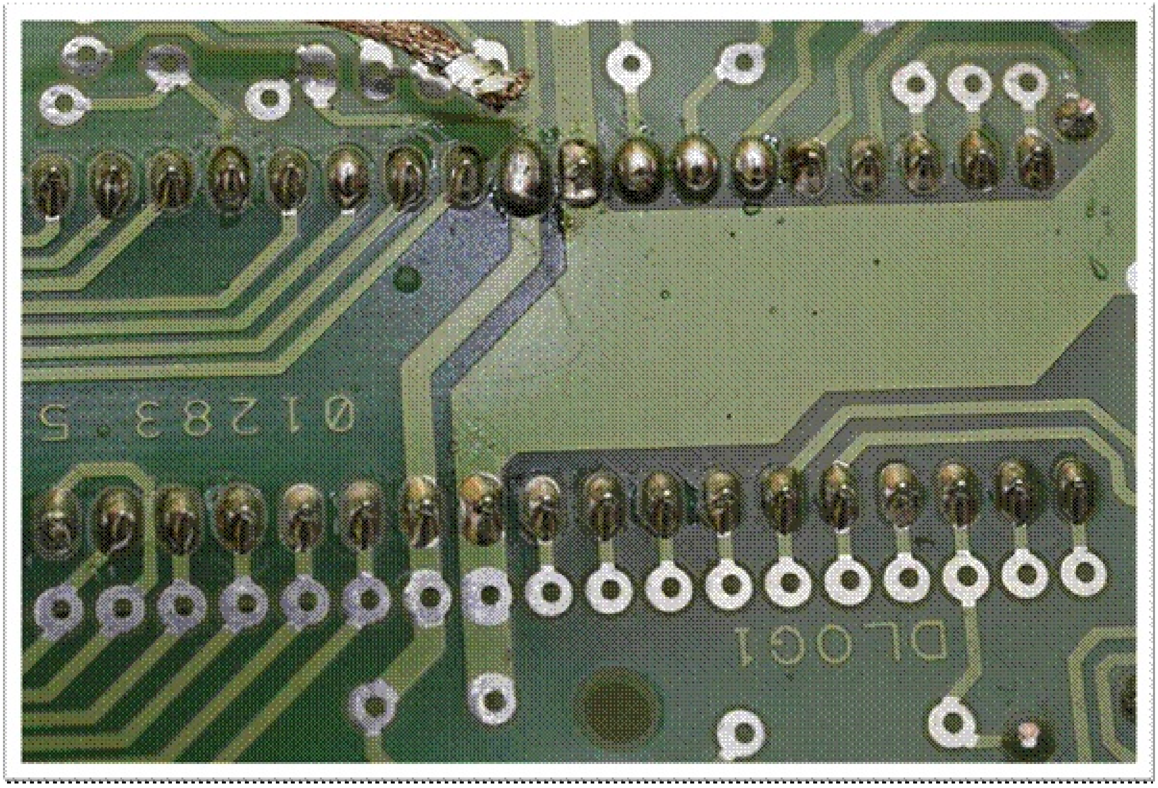
To use desolder braid, press the end of the braid down onto the joint using the tip of an iron, and let the solder melt underneath: the braid will then absorb the solder. The braid becomes hot so beware of burns. Once the solder’s solidified on the braid, cut it off and discard.



^^ *Desolder braid can also be used to remove excess solder, e.g. two i.c. pins shorted together.*



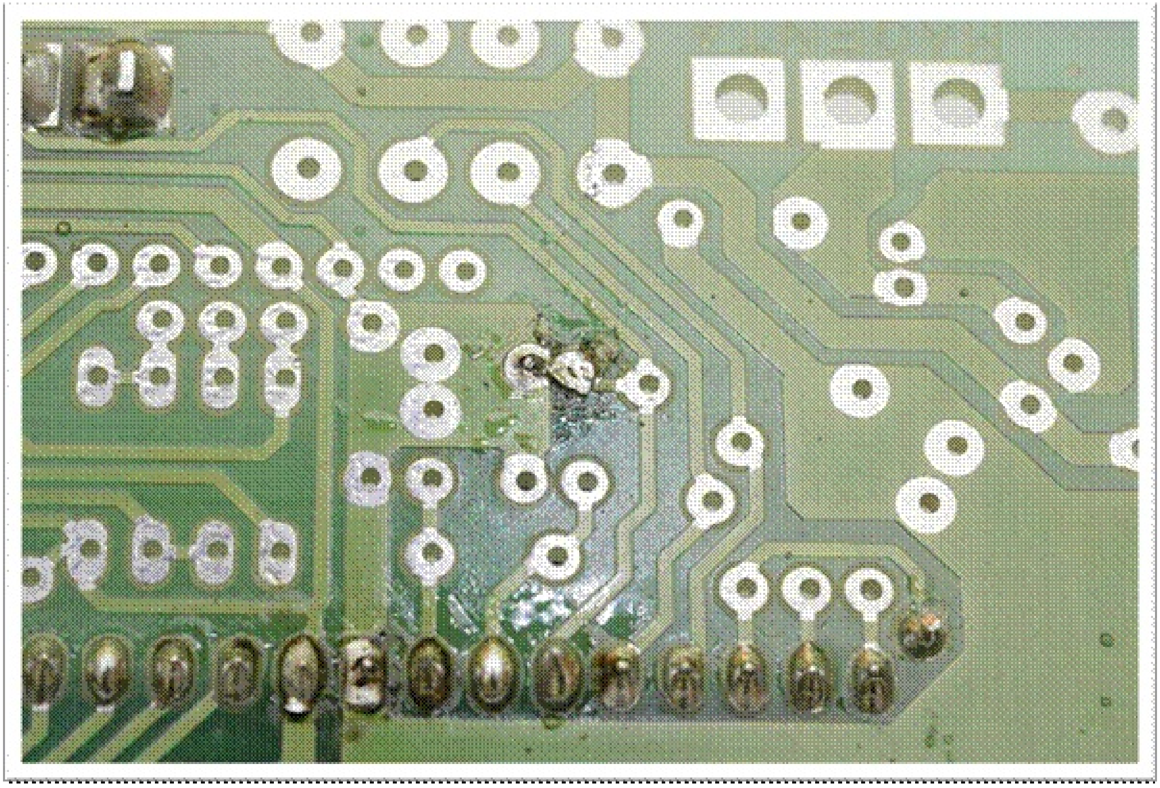
^^ *Press some desolder braid over the joint, then melt it with an iron to draw molten solder up the braid.*



^^ *Remove the braid immediately and don't drag "whiskers" of molten solder around. The excess solder is absorbed by the braid, which is snipped off ready for the next job.*

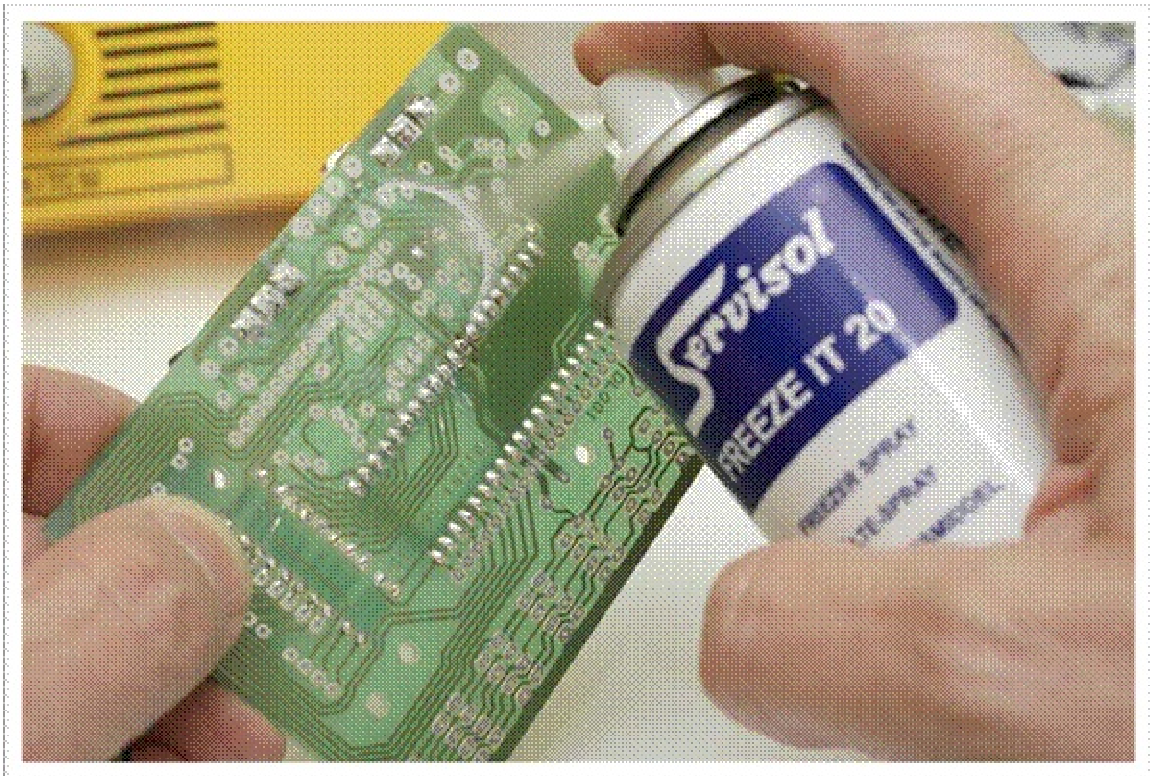
Be aware that you can damage a printed circuit board accidentally when removing the desolder braid if it's not removed *quickly enough*. The solder will soon solidify, which effectively solders the braid to the printed circuit board! A careless tug may yank copper tracks or pads away from the board, stuck to the braid. You can also drag solder "whiskers" onto neighbouring pads unless the braid is removed cleanly. Why not practice using desolder braid with an old circuit board?

Whichever desoldering method you use, care is needed to ensure that the boards and parts are not damaged by excessive heat. It's not that difficult to apply so much heat when desoldering that the adhesive holding the copper foil tracks on the p.c.b. eventually fails, causing the copper track to lift away – everyone's worst nightmare.



^^ Typical copper track damage (centre) caused by overheating during soldering or desoldering. The track has lifted off, but you can try repairing it by adding extra wiring or SuperGlue it if the track isn't broken.

If this should ever happen, remove the iron immediately and permit the area to cool (a freezer aerosol is valuable at such times). If you're lucky, you can maybe repair the lifted track using a droplet or two of Super Glue, or add "jumper wires" to bypass the damage.



^^ A Freezer aerosol can give rapid cooling where excess heat has been applied

during soldering. Also used in circuit faultfinding to identify overheating parts.

You now know everything you need to know about making the ideal solder joint, and desoldering it in case you need to make a repair. Just to remind you, a Quick Summary guide follows.

Quick Summary Guide

To round off the Basic Soldering Guide, let’s summarise how to make the perfect solder joint.

- Ensure materials to be soldered are compatible with tin/ lead or lead-free solder.
- All parts must be clean and free from dirt and contaminants.
- Try to secure the workpiece firmly during soldering.
- Brand new soldering iron tips must be flooded with solder immediately, the first time they are used.
- Wipe the tip of the hot soldering iron on a damp cellulose sponge at frequent intervals. Then “tin” the iron tip by applying a small amount of solder.
- Aim to heat all parts of the joint with the iron for under a second or so, to bring them up to the same temperature.
- Continue heating and apply sufficient rosin-core tin/ lead or lead-free solder to form a complete joint.
- It only takes a second at most, to solder the average p.c.b. joint. It should be smooth and shiny, and through-hole joints should be slightly convex in shape.
- Remove the iron and return it safely to its stand.
- Do not move parts until the solder has cooled.
- Tin the soldering iron tip and clean it well, when switching it off, ready for next time.
- Consider using e.g. electronics flux dispenser pens or Colophony (rosin) to help with difficult joints.

Sometimes solder joints don’t go quite to plan, and sooner or later everyone is faced with the need to problem-solve or troubleshoot, so a simple Troubleshooting Guide follows next.

Troubleshooting Guide

This troubleshooting guide may help fix common problems encountered with troublesome solder joints.

SYMPTOMS	LIKELY CAUSES	REMEDY
Solder won't "take" (wet) and won't flow properly over the joint — molten solder forms beads or "ball bearings" instead of flowing properly.	Grease or contaminants present; Material may not be suitable for soldering with standard lead/tin or lead-free solder, e.g chromium.	Treat contaminated parts with abrasive cleaners etc. as required to expose base metal. Some metals can't be soldered with electronics-grade solder.
Solder doesn't melt or flow very well — the joint is crystalline or grainy-looking - a grey or dry joint.	Joint has been moved before being allowed to cool naturally, or: Joint was not heated adequately. Too large a joint – too much metal present – and/ or the soldering iron temperature or power rating are too low.	Desolder and remake. Apply heat for a longer period, or use a higher power soldering iron, or check the temperature setting and raise it if possible.
Solder joint forms a "spike" and applying the iron again makes it even worse!	Probably overheated, burning away the flux. The iron, when removed, would cause the solder to stand up in a spike.	It is usually best to desolder and remake the joint freshly again.
The copper foil of my p.c.b. has lifted off the circuit board!	Excessive use of heat has damaged the adhesive. Provided the track hasn't broken, it may be repairable.	You can sometimes repair it with Super Glue, or re-wire the board with jumper wires.
Brown varnish-like deposits are left behind after I finish soldering.	These are the remains of rosin flux and are nothing to worry about.	It can be removed with PCB cleaners or some solvents, if you want to tidy up the board and inspect your work.

Possible Hazards and simple First Aid

It's extremely rare that soldering iron operators receive any burns or other injuries from the use of hot soldering irons. Soldering is perfectly safe provided that common sense precautions are taken during the soldering operation. Here are some of them:

- Components are very hot after soldering, so let them cool before handling them to avoid skin burns.
- Beware of splashes of molten solder caused by careless handling of a hot soldering iron.
- Beware of energised components (capacitors, batteries etc.) being shorted by molten solder and ejecting solder splashes due to arcing.
- Always park a hot iron safely on a stand in between use — never hang it vertically next to the bench.
- Keep a hot soldering iron away from its mains cable (silicone cables reduce the risk of accidental damage).
- Beware of wire offcuts flying off (danger to eyesight) when snipping wires to length before or after soldering.
- Avoid inhalation of solder and flux fumes as this can irritate the respiratory tracts, especially in sensitive cases (e.g. asthma).

Should you receive a more serious skin burn which requires attention, then:

- **Cool the affected area immediately.** Use plenty of cooler running water – but avoid ice cubes etc. as they can cause nerve damage after a time or inhibit the flow of blood to the affected area.
- Remove any **objects** which may be constrictive, before any swelling starts (rings, watches, bracelets).
- Do not prick blisters nor apply ointments, salves or lotions at this stage.
- Local pain relief for small burns can be obtained by spraying *Burneze* aerosol onto unbroken skin.
- Seek medical attention for more serious burns.

Eyesight problems are exceptionally rare, e.g. pieces of wire offcuts or solder splashes lodging in the eye area, and should be treated by a qualified first-aider or A&E. The best you can do is bathe the affected area with e.g. a first-aid eyewash bottle or fresh water. Then seek professional medical help straight away.

Useful resources

Details of the Antex range of soldering equipment, solder tips and spare parts can be obtained from www.antex.co.uk. UK and international distributors are also listed on the Antex (Electronics) web site.

If you're interested in hobby electronics then why not try **EPE Magazine**, the No. 1 UK magazine for hobby electronics enthusiasts, students, trainees and technicians around the world. You can buy a printed edition from newsstands, download a PDF version (for Windows) or try a tablet/ smartphone version from Pocketmags. More details at www.epemag.com

You can learn more about the writer at his website http://www.alanwinstanley.com/

Some mail order suppliers of soldering equipment and electronic parts include:

- ESR Electronic Components Ltd. (soldering equipment, Velleman kits)
- Bowood Electronics (Antex irons and spares, electronic parts)
- Rapid Electronics (components, tools, equipment)
- Cricklewood Electronics (CCTV, Antex soldering irons and spares, components)
- Maplin Electronics (UK electronics retailer and mail order)
- Farnell Electronic Components (major UK industrial supplier)
- RS (UK electronics industrial supplier)
- Brewsters Ltd (soldering equipment mail order specialists)
- Velleman UK (electronic kits)
- Quasar Electronics (Velleman kit mail order retailers)
- Kemo Kits (Germany, trade only)
- Hobbytronics (UK hobby mail order supplier)
- Multicore Solders (now a Henkel brand)

These links were correct at the time of going to press, July 2013.

Acknowledgements

Antex (Electronics) UK generously provided samples of their ever popular British-made soldering equipment, materials and accessories for use in the Basic Soldering Guide. When starting out as a 1970's teenage schoolboy electronics hobbyist, I and my trusty Antex soldering iron shared many adventures in electronics together, and it has been a pleasure to use the latest Antex soldering irons throughout this guide.

Also I would like to thank Brian Brooks of Magenta Electronics Ltd. (www.magenta2000.co.uk) for supplying me with a variety of their professionally-designed printed circuit boards and a range of components which were the subjects used in the photographs.

Photography

All photographs were taken by the author using Sony Alpha DSLRs and 50mm macro lens with extension tubes, and a Sony macro flash. High-resolution versions of these and more technical photos are available for commercial or educational royalty-free use. Please contact me with any enquiries.

Conclusion

I really hope the Basic Soldering Guide will give you the confidence to try your hand at electronic soldering. It's really a lot easier than it sounds, and armed with the guide's advice and photographs, the next thing to do is invest in a decent-quality soldering iron such as the excellent range manufactured by Antex that will serve you well for years to come.

Soldering an electronics kit together such as the professional designs produced by Velleman is a great way of testing out your new skills. Start with a small, simple kit costing a few pounds to gain confidence and experience, and avoid the temptation to tackle something too complex until you're ready to extend yourself further.

Feedback is welcomed by email to alan@epemag.demon.co.uk

You can learn more about me at www.alanwinstanley.com or read my column in EPE Magazine.

Good luck with your soldering!

Alan Winstanley

Play fair and support writers who share their skills and expertise

Preparing a resource like this takes months and is based on four decades of practical experience which I gladly share with readers. It costs a small fortune in time, experience, IT and photographic equipment to put an ebook like this together, and the Royalties that you pay to buy the book puts food directly on my table. You paid for your copy (thank you!) so if you see any unauthorised versions of my work anywhere in circulation, I'd really appreciate being told about it. Thank you! A.R.W.

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Learn to Solder

Tools and Techniques for Assembling Electronics

Brian Jepson,
Tyler Moskowite
& Gregory Hayes

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by Brian Jepson, Tyler Moskowite, and Gregory Hayes

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Contents

Welcome

Welcome to MAKE's Getting Started with Soldering Kit, and congratulations on taking a big step into the world of DIY electronics. Once you get the hang of soldering, you can put together some of the many great kits that are available, fix electronics that are broken, and build inventions of your own. With this kit, you'll learn how to:

- Prepare and clean your soldering iron
- Assemble electronic circuits from kits
- Transfer circuit designs from a solderless breadboard to a prototyping PCB
- Correct soldering mistakes you've made

Basic Tools

There's a lot of great stuff in the box, and before you start using it, here's a tour of what you'll find in there. Figure 0-1 shows the soldering tools you'll be using most of the time.

Figure 0-1. *Basic soldering tools*

Deluxe soldering iron
: (Top left) This soldering station includes a variable temperature controller, a cleaning sponge, soldering iron, and a ringed holder.

Crosscut pliers
: (Left) You'll use these to trim away excess leads after you solder components in place.

Solder tube
: (Bottom) This is enough solder to get you started and keep you busy over many projects.

Helping hands
: (Right) For those times when you need a third or fourth hand, the helping hands let you hold items steady while you solder.

Advanced Tools

Most of the time, you'll only need the basic tools to get things done. But when you need to replace your soldering iron tip, correct a mistake you made while soldering, or need a tool to help keep components from overheating, you'll need the items shown in Figure 0-2.

Figure 0-2. *Advanced soldering tools*

Heat sink
: (Left) Clip this to sensitive components to help dissipate heat.

Desoldering wick
: (Bottom left) Use this to wick away excess molten solder.

Desolder pump
: (Center left) This pump will suck up molten solder when you have a lot of solder to remove.

Soldering tools
: (Center right) The scrapers, brush, and slotted probe come in handy when you need to move solder around or precisely position a component.

Replacement tips
: (Right) Tips don’t last forever. When you’ve worn out your tip, use one of these as a replacement.

Project 1: Learn to Solder Skill Badge

Our Learn to Solder Skill Badge Kit (the 2011 model is shown in Figure 0-3) has been used to teach thousands of people of all ages how to solder at Maker Faires across the country. It's a simple, fun way to learn how to solder and also how to teach others to solder. After you build the one included in the box, you can order more from *makershed.com* and teach others how to solder.

Figure 0-3. *Learn to Solder Skill Badge, 2011 model*

Blinking or Color Change LED
: (Top left) This is an LED (Light-Emitting Diode) with a twist. Normal LEDs give off a single color, and keep shining as long as you give them power. Also, normal LEDs require a specific voltage to operate: don't give it enough power, it won't light at all; give it even a little too much, and you could burn it out.

This LED is different in both respects: it has three elements (red, green, and blue) that are under the control of a small integrated circuit (IC) embedded within the LED. The IC causes the elements to change color in a repeating pattern. Because the IC controls the voltage that it delivers to the individual color elements, it's more tolerant of variations in the voltage you give it. For example, even though red LED color elements typically operate at around 2 volts, you're able to use a 3 volt battery with the pin.

The 2012 model uses two self-blinking LEDs instead of one self-color changing RGB LED.

CR1220 battery
: (Lower left) This "coin cell" battery supplies power to the pin.

Printed Circuit Board (PCB)
: (Center) The 2011 Learn to Solder Skill Badge features a friendly robot. The 2012 model will also have a robot, every bit as friendly.

Pin and clutch
: (Top right) This is what holds the pin to your clothing.

Battery holder
: This keeps the battery on the PCB.

Project 2: 555 Timer Blinky

The 555 timer blinky is a simple circuit that makes two LEDs flash in an alternating pattern. When one is on, the other is off. Figure 0-4 shows the components for this project, and Figure 0-5 shows the finished project. This is a slightly more challenging project than the skill badge.

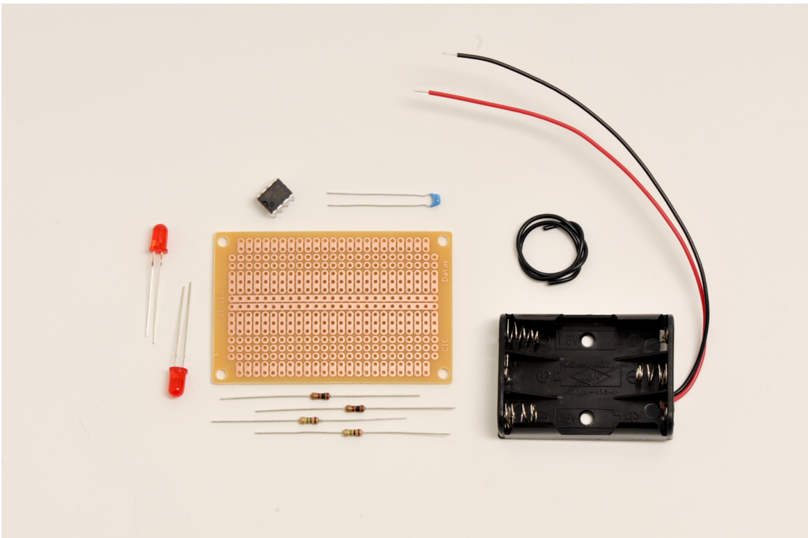

Figure 0-4. *555 blinky parts*

LEDs
: (Left) Unlike the LEDs used in the skill badge, these are your normal, run of the mill LEDs.

Protoboard
: (Center) Look back at the skill badge PCB. Notice how it was custom designed for a single purpose. Now look at this protoboard PCB: it's got a lot of different holes in convenient locations. You can build many kinds of simple electronics projects on a board like this.

555 Timer
: (Top left) The 555 timer is a special type of integrated circuit that can turn electrical current on and off in a repeating pattern. It's just what you need to blink an LED.

Capacitor
: (Top right) To customize the 555 timer, you need to connect certain components to it. The value (capacitance or resistance) of the component determines how quickly the 555 turns things on and off.

Hookup/Jumper Wire
: (Top right) You'll need this to connect one thing to another.

Resistors
: (Bottom) Resistors serve two purposes here: two are used to make sure the LEDs don't get too much current; the other two work with the capacitor to control the behavior of the 555 timer.

Battery Box
: (Right) This holds 3 AAA batteries.

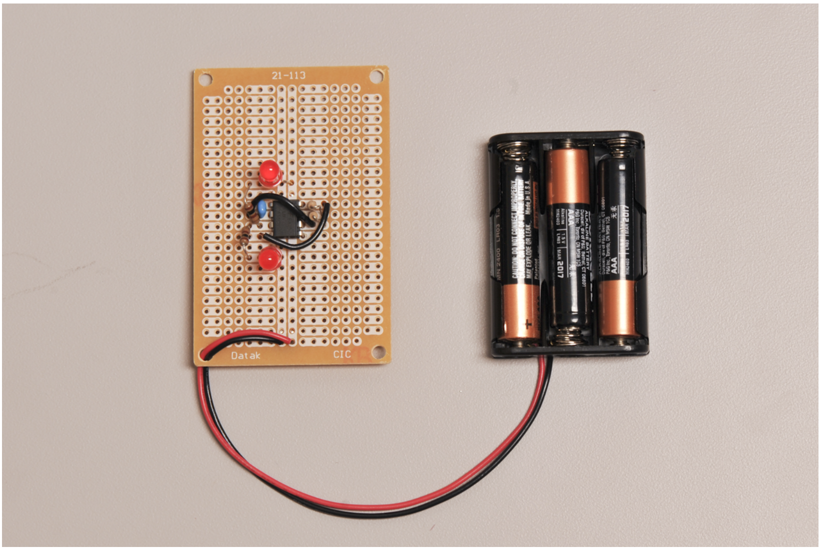

Figure 0-5. *Finished 555 blinky*

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1/Getting the Workspace Ready

Before you can start soldering, you need to get your iron ready. This involves a few steps. First, you'll have to attach the tip to the soldering iron. Then, you'll need to prepare the station: make sure your sponge is moistened, set the temperature, and "tin" the tip by applying some solder to it.

At the end of this chapter, your soldering iron will be assembled, clean, and hot enough to begin soldering.

Solder contains harmful chemicals. Wash your hands after soldering as well as after handling solder or the solder station sponge. Though it may be tempting to snack while you're working, keep any food or drink away from your soldering area.

1: Attach the Tip

Locate the soldering iron (make sure it's unplugged and cool), a soldering iron tip, and the tip nut that holds the tip in place. Insert the tip into the soldering iron as shown in Figure 1-1, and push it in as far as it will go. It will not require much force to insert it.

WARNING: Make sure the soldering iron is unplugged and cool.

Figure 1-1. *Inserting the tip into the tube*

2: Secure the Tip

Slide the tip nut over the tip, and screw it in place. You can use pliers to tighten it (see Figure 1-2). Be careful not to overtighten it, since you will eventually need to replace it when the tip gets worn from all the projects you'll be making with it.

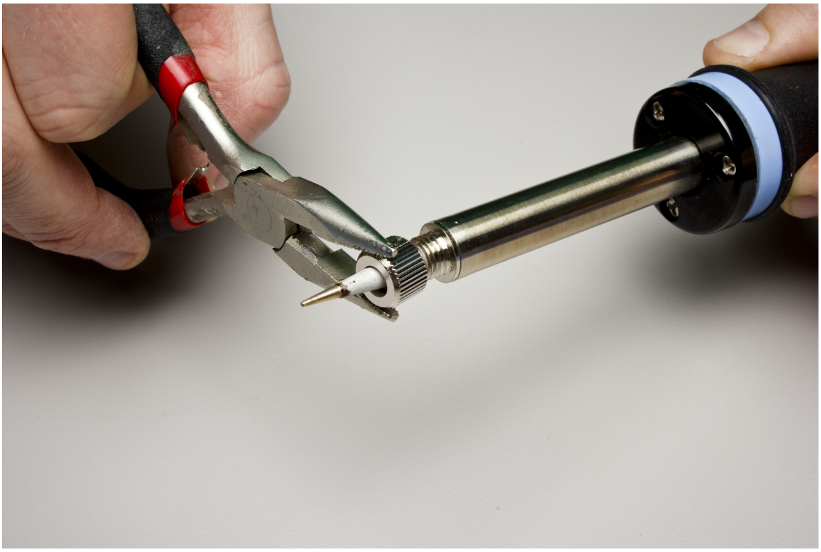


Figure 1-2. *Making sure the tip stays put*

WARNING: Over time, the tip nut might become loose. Let the iron cool down before you tighten it.

3: Wet the Soldering Station Sponge

You'll need to perform this step (and the remaining ones in this chapter) at the beginning of each soldering session.

As you use the soldering iron, you're going to be wiping the tip a lot, so you need to keep the solder station sponge moist. Pour a little clean, fresh water on the sponge as shown in Figure 1-3. Don't soak it, but make sure it's completely moistened.

NOTE: If your water has a high mineral content, use distilled water for wetting the sponge.

Figure 1-3. *Wetting the sponge*

4: Set the Station's Temperature

Plug your soldering iron in, and set the heat setting to the mark shown in Figure 1-4 (pointing at the 3 o'clock position on the dial). Give the iron a couple minutes to warm up.

Figure 1-4. *Setting the temperature*

WARNING: The iron will get very hot, and certainly hot enough to burn you. Don't touch the tip and don't touch the tip to anything other than solder or components you are soldering together.

5: Wipe the Iron's Tip

Wipe the tip on the sponge as shown in Figure 1-5, being sure to turn the iron a few times as you wipe it, so you wipe all of its surfaces. It will make a sizzling sound as the water in the sponge comes into contact with the tip. The figure shows a sponge that's been used a few times. Notice the little blobs of solder that have come off the tip over time. A clean tip is critical to successful soldering. Even a small layer of oxidized material or other crud will limit the amount of heat that's transferred to the component you're soldering. Wipe the tip often, and keep the tip clean.

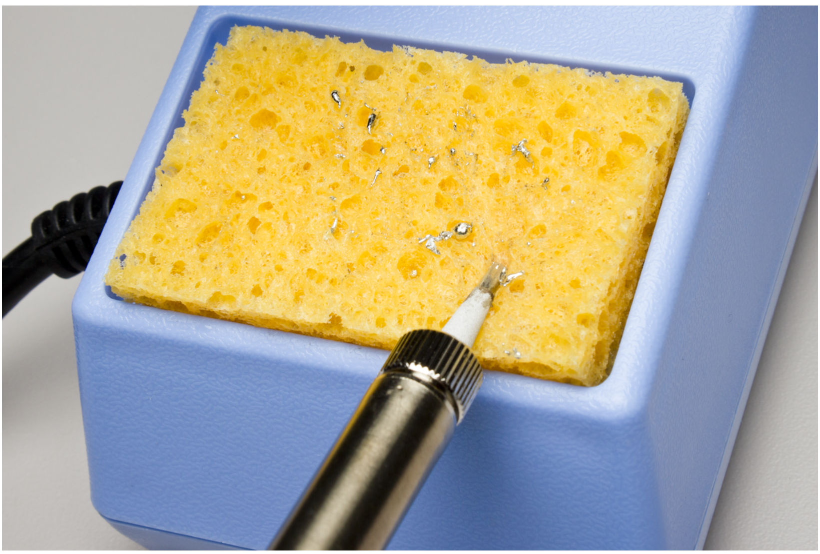


Figure 1-5. *Wiping the tip clean*

6: Tin the Iron's Tip

Before you begin soldering components, you should put a thin layer of solder on the tip as shown in Figure 1-6. This will have two effects: burning off any crud that shouldn't be there, but also providing a thin layer of liquid solder. This layer makes for a very effective heat transfer between the soldering iron and whatever you're soldering. Give the tip one more quick wipe on the iron and place the soldering iron into the holder until you need it.

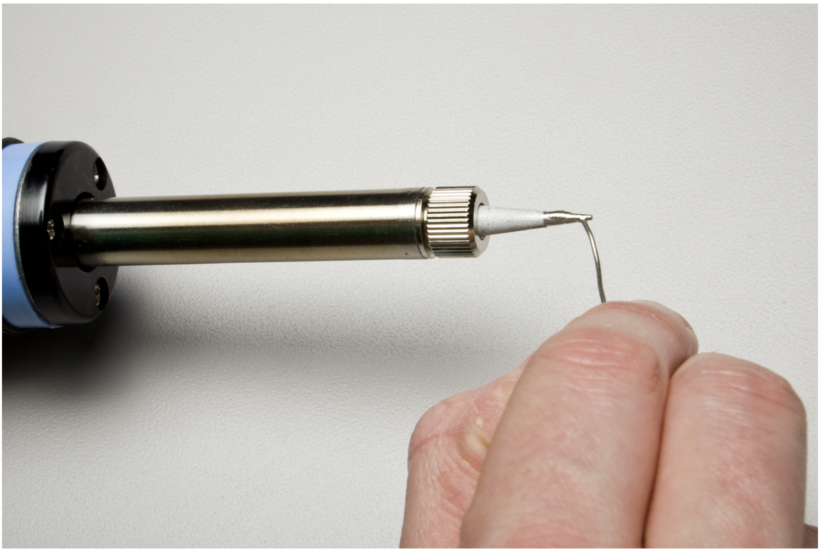


Figure 1-6. *Tinning the soldering iron tip*

NOTE: A small puff of smoke will appear as the *rosin flux* in the center of the solder is activated. The rosin serves two purposes: to clean the soldering iron (and the joint that you are soldering) and to help the solder flow freely. Avoid inhaling this smoke.

Go Make Your Learn to Solder Skill Badge

With your workstation all set up, you're ready to try your hand at soldering. The Learn to Solder Skill Badge ("Project 1: Learn to Solder Skill Badge" on page viii) is a great place to start. It's so simple, we think you can even try it before you read any more. But before you try the second project ("Project 2: 555 Timer Blinky" on page x), you should definitely give the rest of this guide a read.

2/How to Solder

With your soldering iron prepped, you're ready to begin soldering. This chapter has many helpful tips and techniques for soldering effectively, safely, and neatly.

Working with Solder

Solder is made of metal with a core that contains flux, which cleans the connection as you solder. When the metal melts, the flux begins to flow onto the joint. Some solder lead-based, but the solder in this kit is lead-free. To melt solder, heat it with the soldering iron as shown in Figure 2-1.

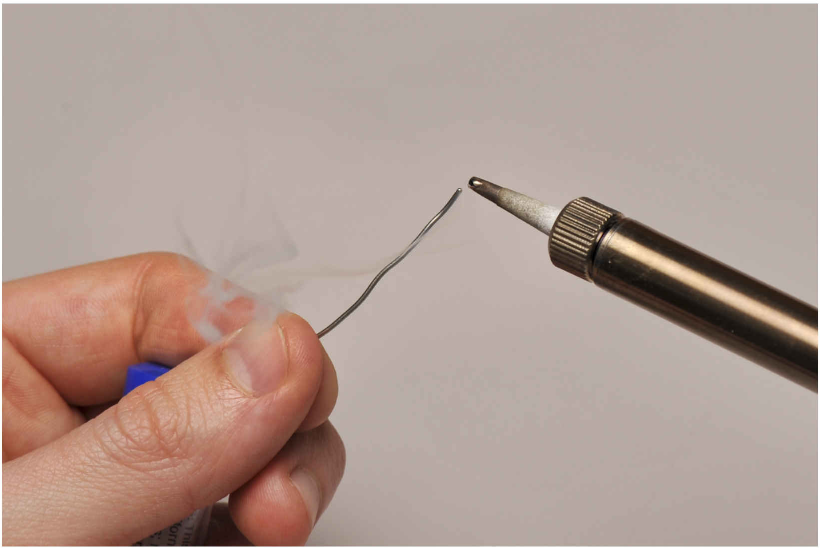


Figure 2-1. *Melting some solder*

Try melting some solder, but be careful not to drip it on yourself or anything other than a work surface. You can try pushing tiny balls of solder around on your work surface to see how it flows. If you have some bare hookup wire or similar metal, try heating it up by holding the soldering iron to it (don't hold the wire while you're heating it). Touch a piece of solder to the wire, but

choose a point that's an inch or so from where the soldering iron is touching. How close do you have to get to the soldering iron tip before it melts?

Keeping the Circuit Board from Moving

When you're soldering, you've got a lot to juggle: the soldering iron, the solder, and the two things you are connecting to each other. The helping hands let you place the items you're soldering in a stable position. Use the clips to hold the item in place as shown in Figure 2-2. But once you start inserting items into the board, you need some way to keep them from moving. "Placing a Component in the Board" on page 11 shows you how to do that.

Figure 2-2. *Holding a PCB in the helping hands*

Tinning Solder Pads

You'll sometimes come across things that need a layer of solder to work right. For example, on the Learn to Solder Skill Badge, you need to put a bump of solder in place to give the battery a snug fit. With solder pads that are this big, you need to heat the pad with the iron really well; the pad is so large that it's going to take longer to heat. It's best if you melt the solder by pushing it onto the pad rather than pushing it directly against the iron. This makes sure that the solder flows thoroughly over the pad. If the solder doesn't melt, try tinning the tip again first.

Start with a little blob as shown in Figure 2-3, and spread it around evenly. When you've got the desired thickness, first pull the solder away, then pull the soldering iron away. Doing it in this order will avoid leaving chunks of solder behind.

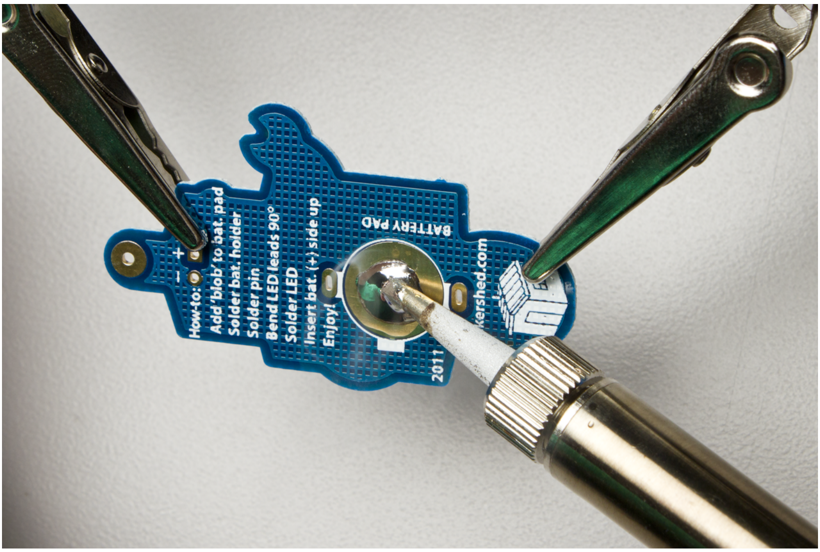


Figure 2-3. *Laying down some solder*

Placing a Component in the Board

You don't want components falling out of the board while you're soldering. In fact, you'll often insert a component with the board upside down (see Figure 2-4), then flip the board over when you put it in the helping hands. So the components have plenty of opportunity to fall out. To keep the component in place, bend the leads out as shown in Figure 2-5.

In some cases, you may need to quickly tack a component in place to keep it from moving. See "Stabilizing and Straightening Components" on page 14.

Don't try to place every component at once. Start with low-profile (shorter) components, solder them in one at a time, and move on to higher-profile components.

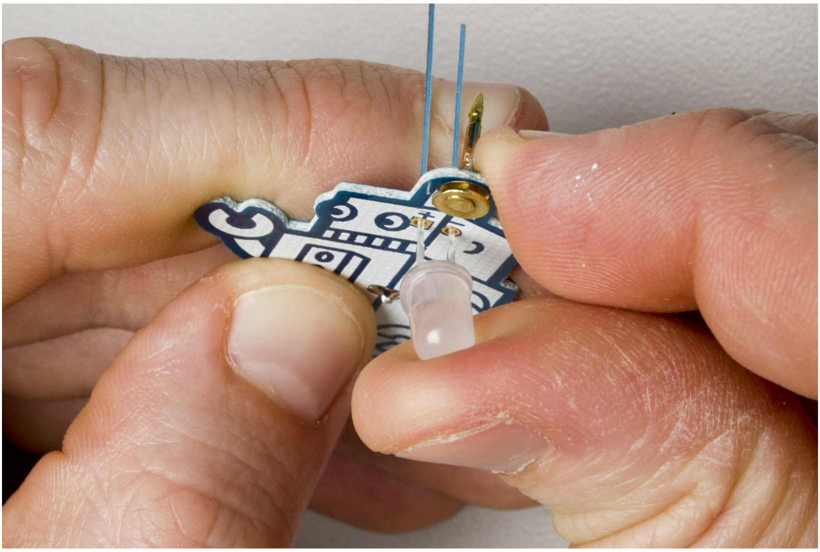


Figure 2-4. *Inserting an LED*

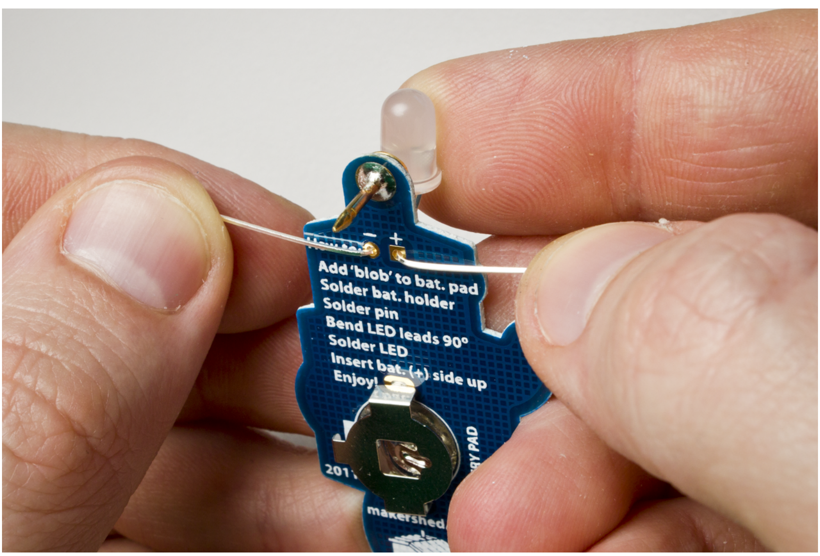


Figure 2-5. *Bending out the leads*

Knowing Which Way a Component Goes In

Some components don't care which way you put them in: resistors, some capacitors (such as the one that comes with this kit), and many other components fall into that category. On the other hand, LEDs are *polarized*; electrical current will only flow through them in one direction. So if you put your LED in backwards, it won't light up at all. You can determine an LED's polarity in a couple of ways: First, the longer of the two leads is the positive (+), and the shorter is negative (-).

Second, look closely at the bottom of the LED and examine the ring that bulges out around it. There is a flattened part of that ring that indicates the side of the LED that's negative (-). You can see this flattened side on the right in Figure 2-6.

With ICs, this also matters. Every pin has a specific function, and there will be one or more pins for positive (+) and one or more pins for negative (-).

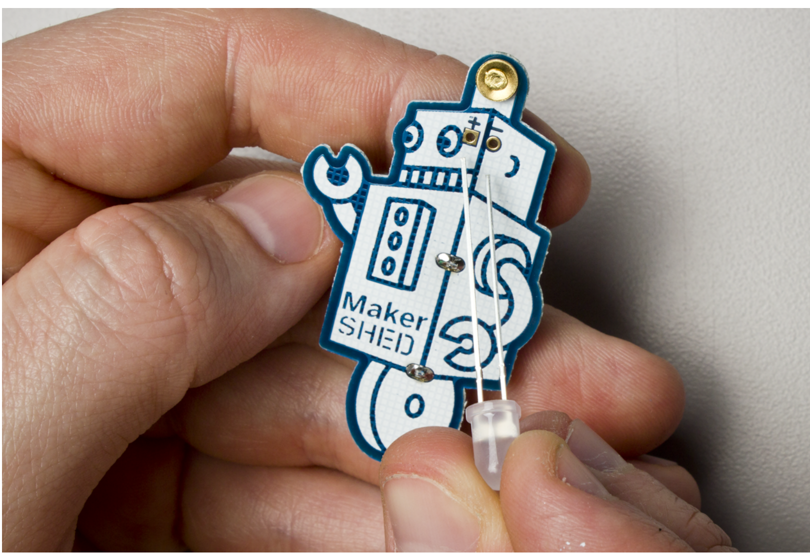


Figure 2-6. *Polarity—LEDs have it*

Stabilizing and Straightening Components

ICs present a unique problem. They don't have long enough leads for you to bend out effectively, which means they are more likely to slip and slide while you're soldering them. So do the best you can with that (see Figure 2-7), but flip the board back over after you solder the first joint. In most cases, you'll find that the IC has shifted. But since you only have one joint soldered, you can easily move the IC into the position you want. Once you've done this, flip the board over and solder the remaining connections.

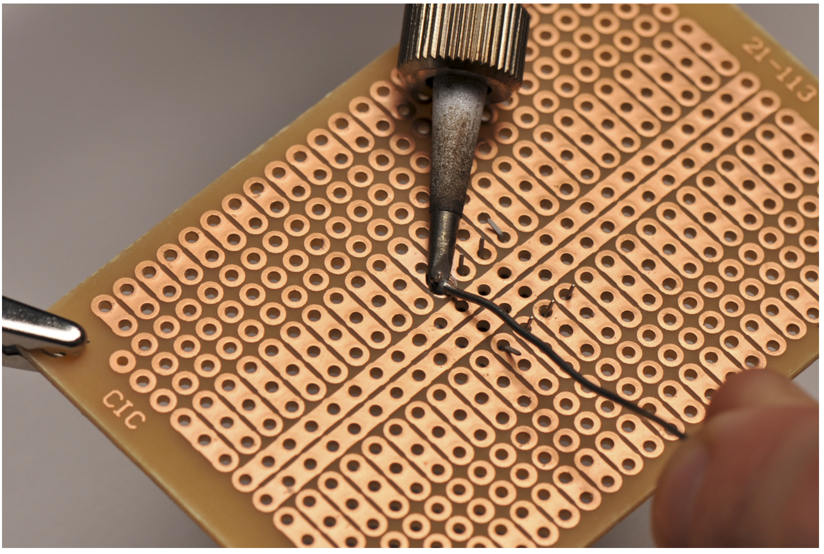


Figure 2-7. *Tacking down an IC*

Safely Soldering Sensitive Components

You need to avoid applying too much heat to a component, or you might damage it. One way to help avoid this is to clamp the heatsink to the component as shown in Figure 2-8. This will draw heat away from the component, protecting it somewhat.

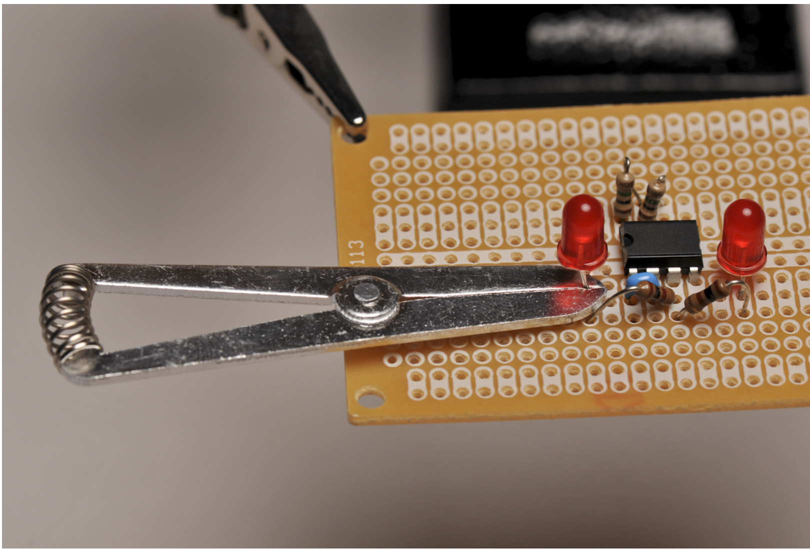


Figure 2-8. *Keeping heat away from the component*

Soldering a Component in Place

Wipe the soldering iron on the sponge and hold it so it's touching both the solder pad and the lead that protrudes through. Avoid using the soldering iron to melt the solder. Instead, heat up both the lead and the pad so that the solder melts when you touch it to them.

This must all be done quickly: within a second of touching the iron to the joint, push a small amount of solder into the joint, and let it flow around the joint as shown. Give it a second to flow, take the solder away, then wait a second, and take the iron away. With practice, you should be able to do all of this in three to four seconds per joint. Figure 2-9 shows how you'd solder the pin to the skill badge. Figure 2-10 shows an LED being soldered.

If you hold the iron to the component too long, you run the risk of damaging either the component or the solder trace on the PCB.

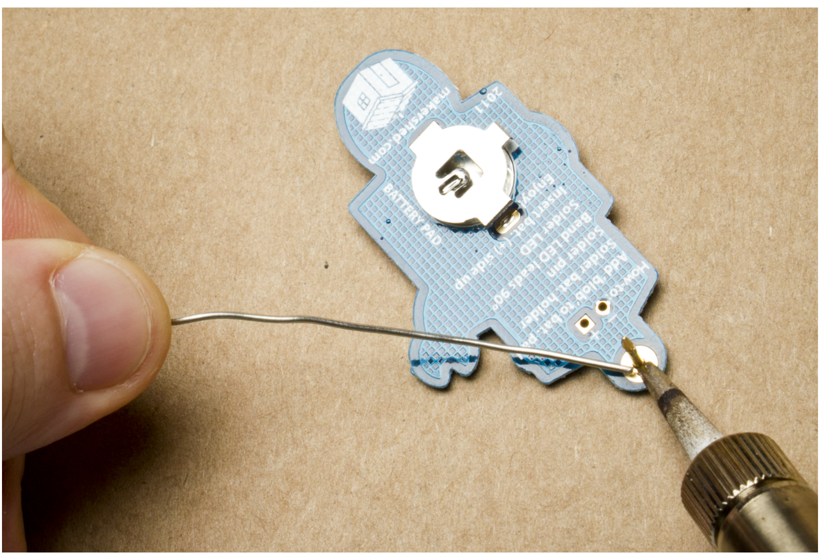


Figure 2-9. *Soldering a pin*

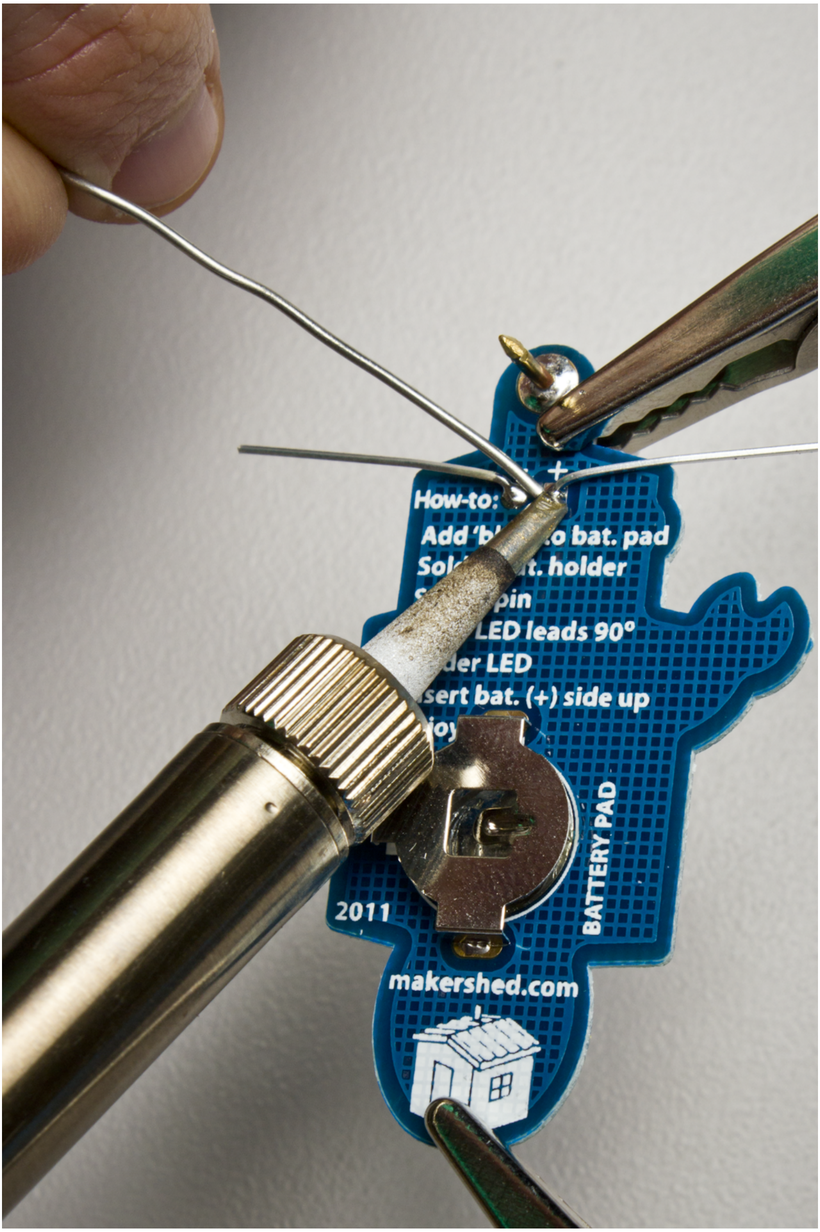


Figure 2-10. *Soldering an LED*

Trimming Your Leads

After you solder a component in place, you need to tidy things up. Grab the cutters from your kit, and trim the leads as close to the solder joint as possible (see Figure 2-11 and Figure 2-12). Don't cut into the solder joint; the idea is to trim the excess wire lead.

When you clip it, the wire lead will fly away from the clippers very fast, and could injure someone. The best way to keep this from happening is to use one or two fingers to hold the lead you're clipping. With one finger, you can put enough pressure on it to keep it from flying away.

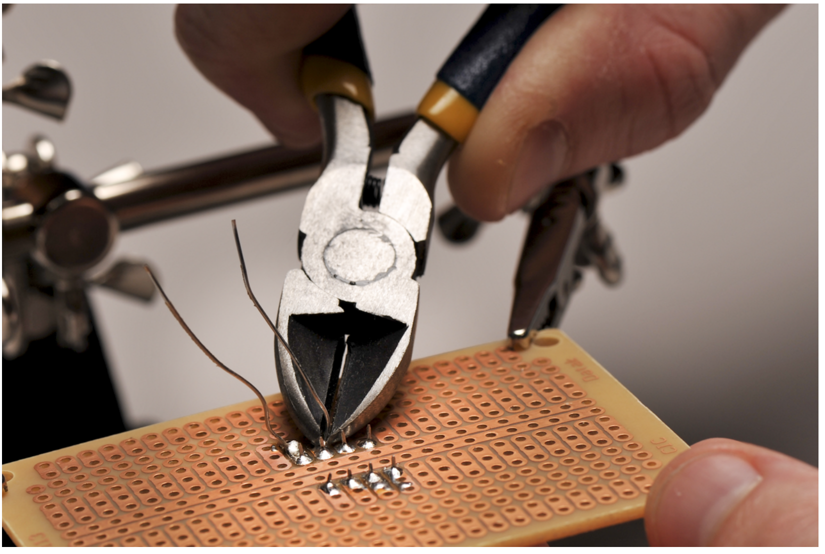


Figure 2-11. *Trimming leads on the 555 blinky*

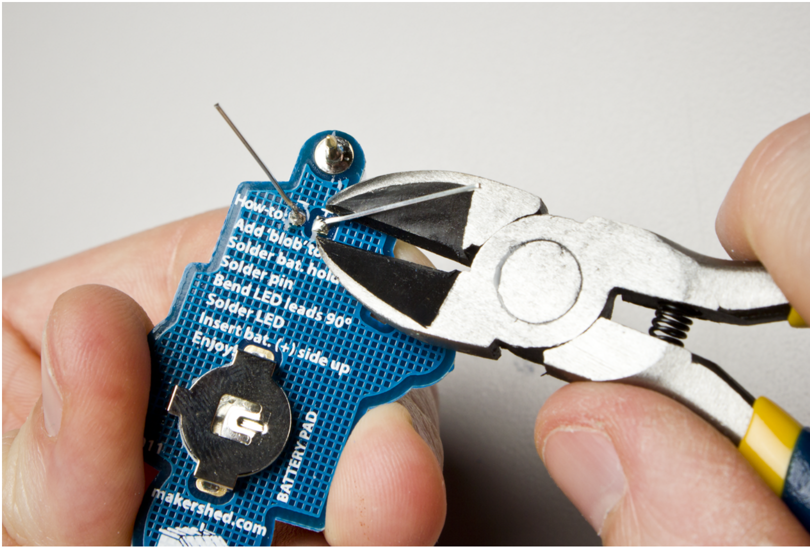


Figure 2-12. *Trimming leads on the Learn to Solder Skill Badge*

Going From Solderless Breadboard to PCB

The beauty of protoboard is that it mirrors the layout of a solderless breadboard, which is used for prototyping electronic circuits. Once you have your project laid out and working on a breadboard, you can easily transfer it to the protoboard. As with a solderless breadboard, the protoboard has rows and columns that are tied together. The layout is slightly different, though. Where the breadboard has two rails (one for positive, one for negative) on both the top and bottom as shown in Figure 2-13, the protoboard that comes with this kit has its rails in the center of the board.

Figure 2-14 shows the project from Figure 2-13, but laid out on a protoboard instead of the solderless breadboard.

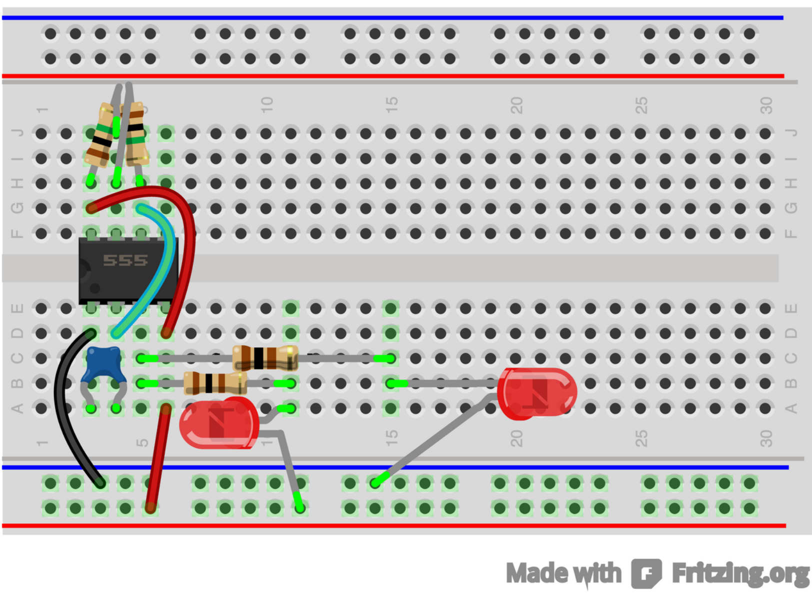


Figure 2-13. *The 555 blinky project on a breadboard*

NOTE: The breadboard diagram in Figure 2-13 was made with Fritzing, an open-source initiative to support designers, artists, researchers and hobbyists to work creatively with interactive electronics. For more information, see *http://fritzing.org/*.

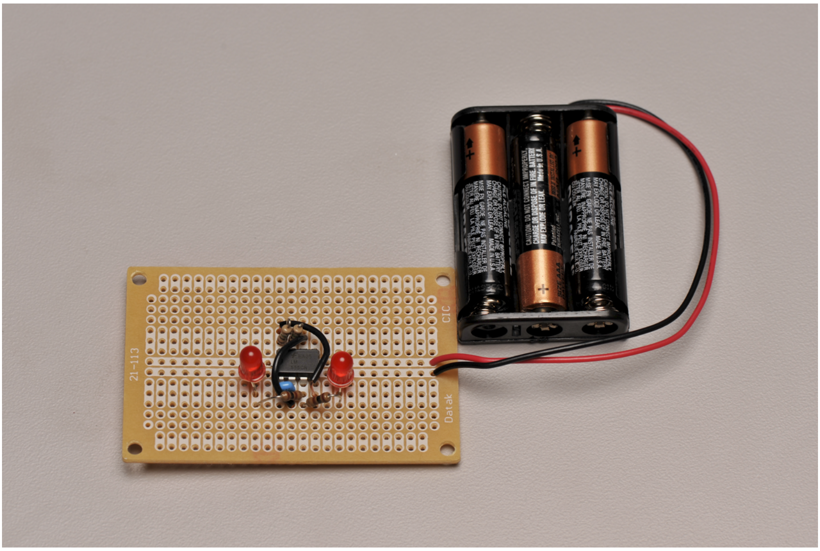


Figure 2-14. *The 555 blinky project on a protoboard*

Soldering Jumper Wire

Jumper wire can be treated a lot like other components (see “Placing a Component in the Board” on page 11): make sure there’s enough bare wire poking through so you can bend it outward enough to hold it in place. The notched probe included with this kit can be helpful with placing jumper wire in the right place (see Figure 2-15).

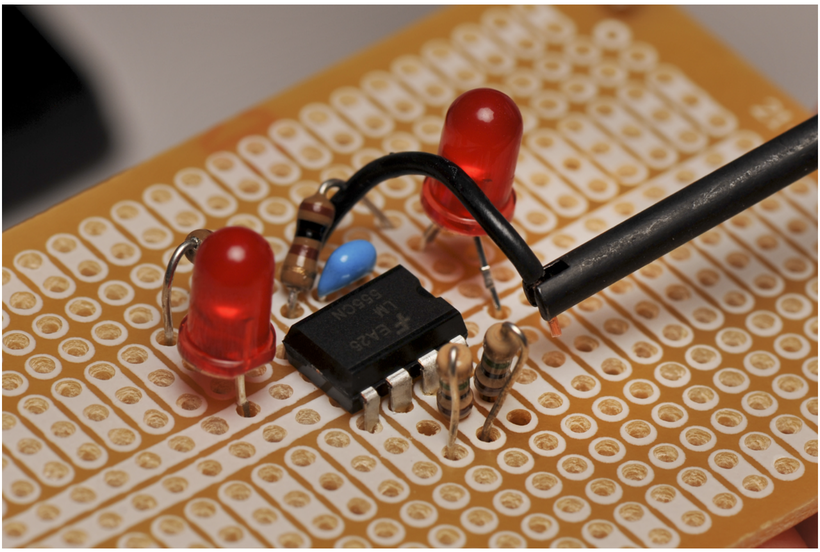


Figure 2-15. *Placing the jumper wire*

Bridging Joints with Solder

When you’re working with the protoboard, you will sometimes need to bridge joints that are close to each other. This is preferable to using jumper wire since your board remains uncluttered on the top. It doesn’t always look great on the bottom, though, because you end up with a lot of solder in some places. Figure 2-16 shows the start of a bridge: feeding the solder into the gap between solder joints. Figure 2-17 shows a bridge being formed.

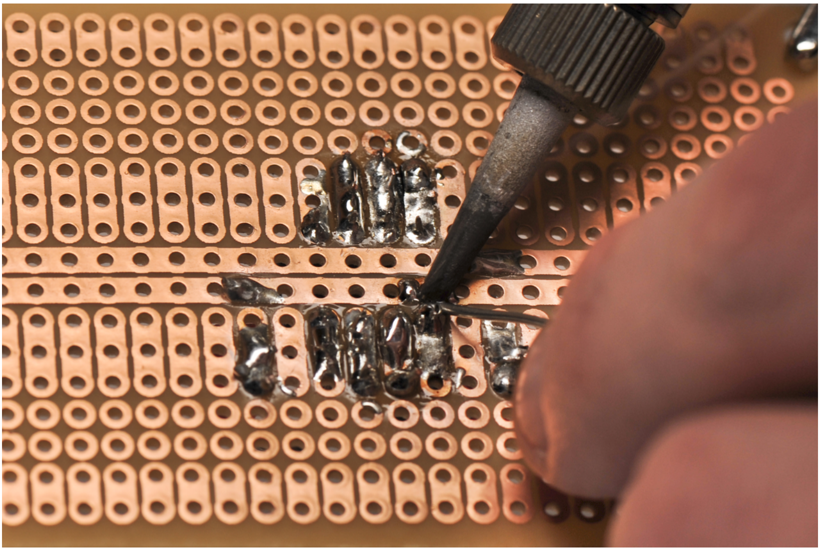


Figure 2-16. *Feeding solder into a gap*

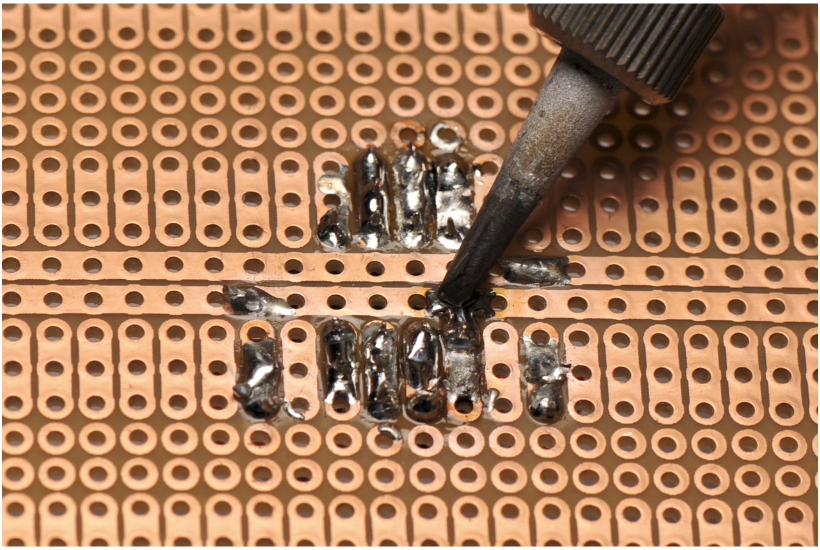


Figure 2-17. *Forming a bridge across the gap*

Relieving Strain on Cables

If you have something heavy dangling off your board, such as a battery box, it's very likely that the solder joints will come undone. If you pass the wires through the large holes on the board before soldering them down (Figure 2-18), you can add some strain relief (Figure 2-19) that will help prevent this from happening. If you have a small drill, you can also drill out a couple of holes close to where you are going to solder the connection, and loop the wire through there. This will be even more rugged than using the larger holes.

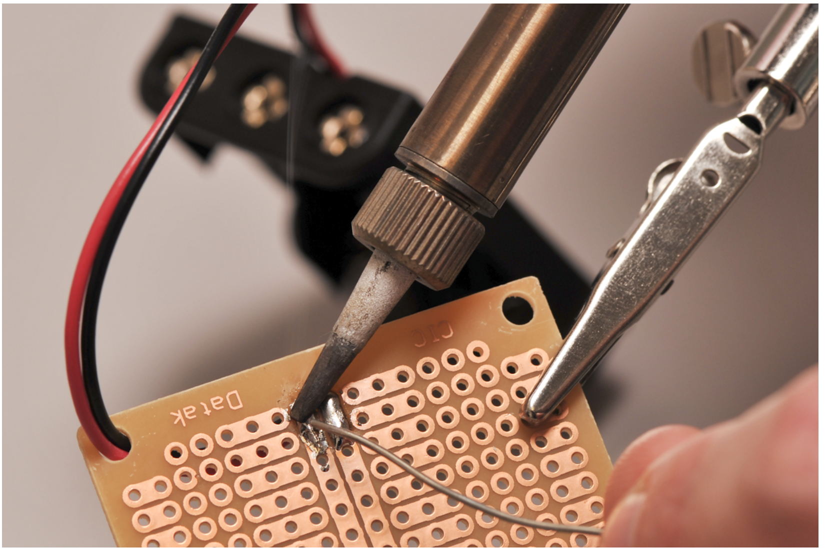


Figure 2-18. *Soldering the battery holder wires*

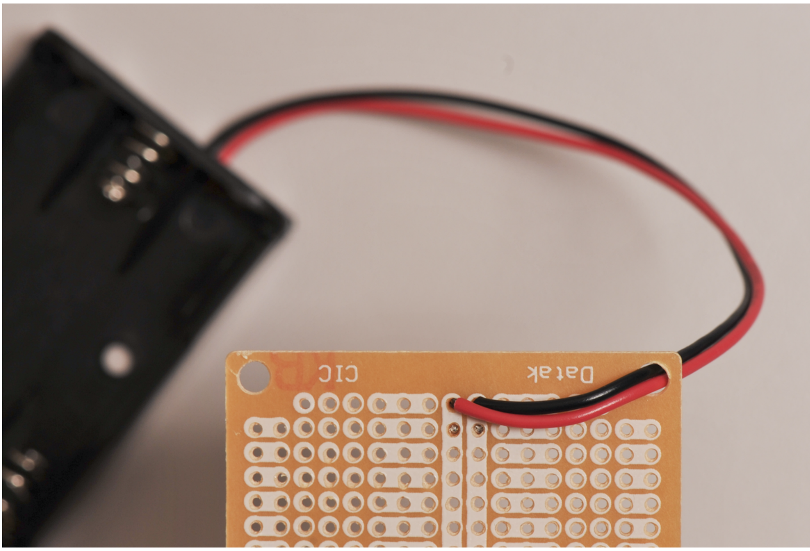


Figure 2-19. *Strain relief*

Getting the Perfect Solder Joint

It's not hard to get a great solder joint, but it's also easy to be sloppy. Here are some pictures of good and bad joints to help you out.

Figure 2-20
: Here's a good solder joint on the positive (+) pad: solder surrounds the joint and makes a little peak. This joint had just the right amount of solder and just the right amount of heat.

Figure 2-21
: The joint on the negative (-) pad is sloppy. The solder didn't flow around the joint, and some of it is spread out across the lead. You can try to fix it by holding the iron to the joint for a couple seconds; the solder should flow down the lead and onto the joint.

Figure 2-22
: The joint on the positive (+) pad has too much solder, and it's balled up. You can use the desoldering wick or solder sucker to remove the excess. After you do that, hold the iron to the joint for a couple seconds to get the solder to flow around it.

Figure 2-23
: Here are two joints for comparison: one good, one blobby.

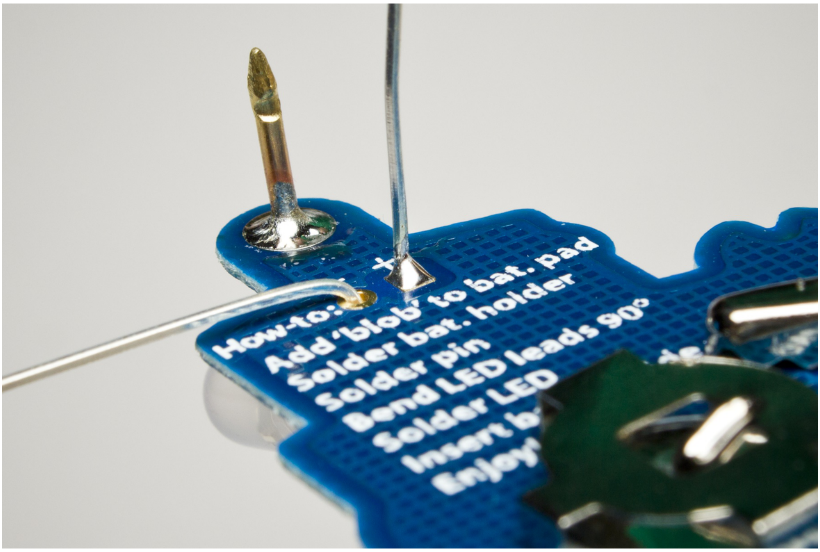


Figure 2-20. *A good solder joint*

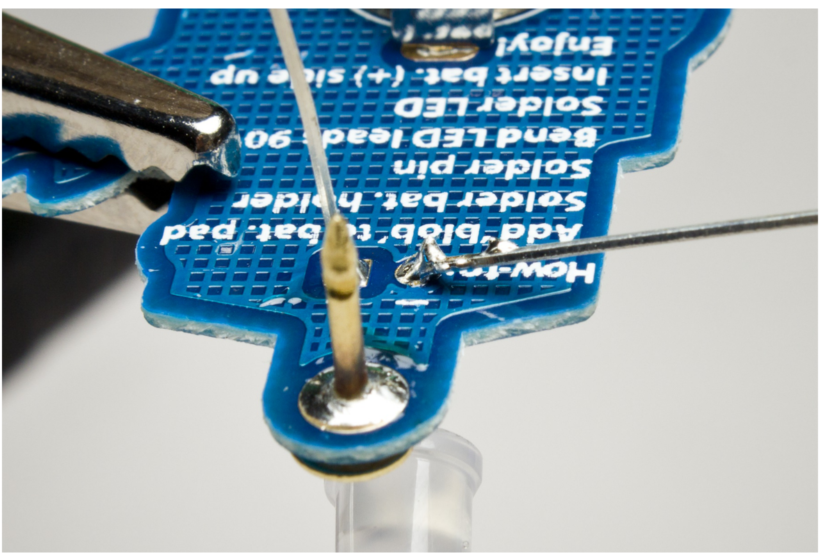


Figure 2-21. *A messy solder joint*

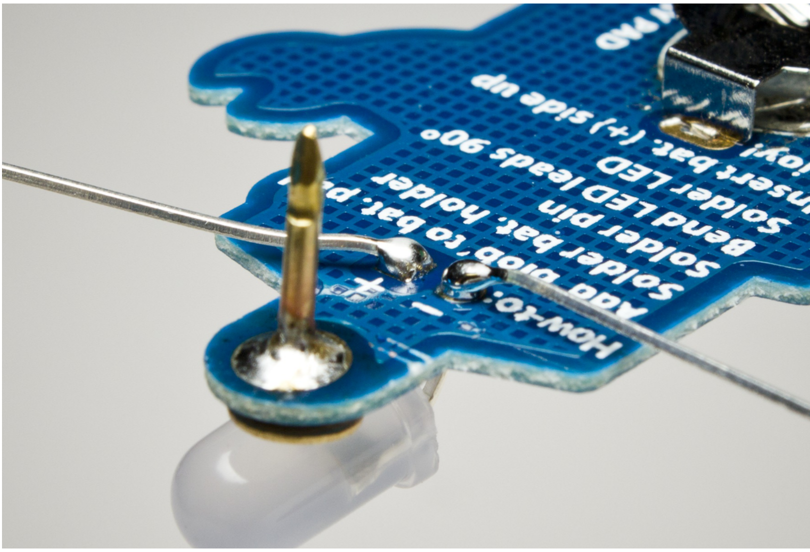


Figure 2-22. *A blobby solder joint*

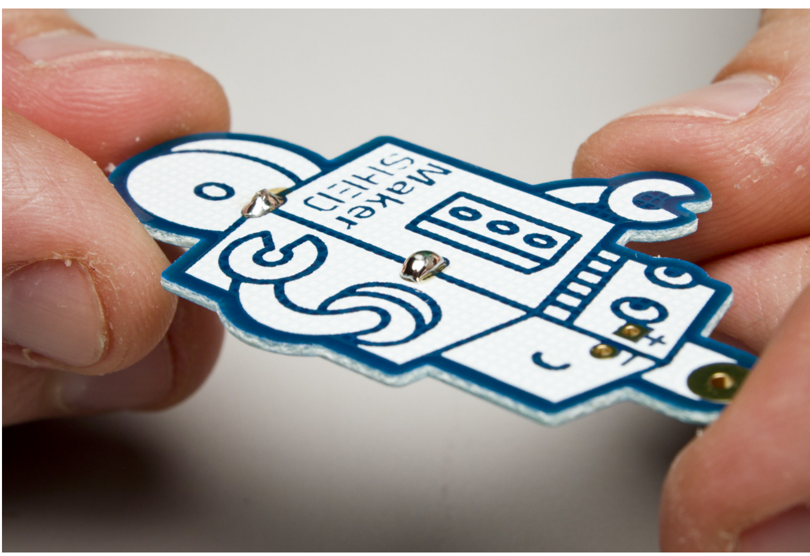


Figure 2-23. *Comparing two joints*

3/Desoldering

If everything went right the first time, you'd never learn anything. This section shows you how to recover from little soldering mistakes, and also includes a gallery of various solder joints so you can compare your work.

Desoldering is the "undo" command for soldering. With this technique, you can remove solder from a joint, allowing you to free the component so you can reorient it as needed. There are two tools for this: the *desoldering wick* (sometimes called *desoldering braid*) and the *solder sucker*.

The Desoldering Wick

Pull a small length of wick out of its spool (Figure 3-1). You don't need much, but if you don't use it all, you can wind the wick back into its spool.

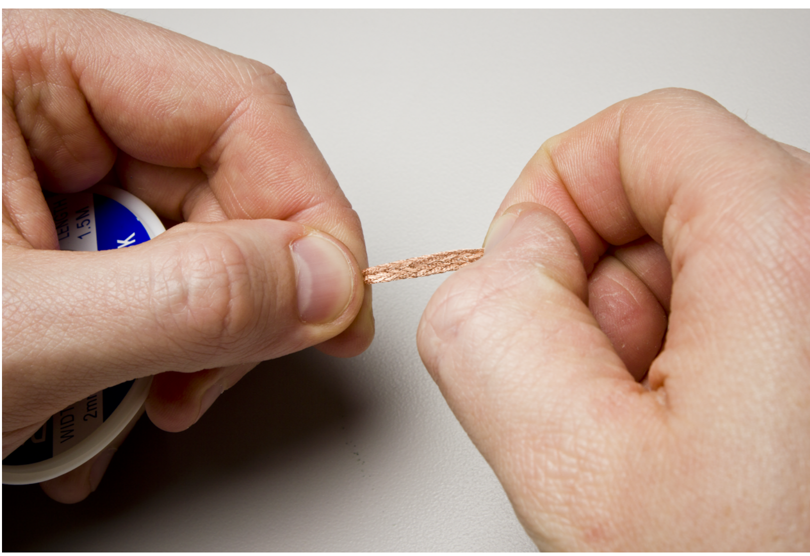


Figure 3-1. *Pulling out some wick*

Preparing the Wick

Before you use the wick, hold it as shown in Figure 3-2, and push inward. This will cause the wick to spread out, giving you more surface area to work with.

Figure 3-2. *Spreading the wick*

Desoldering with the Wick

Position the wick over the joint, and press down on the wick with the soldering iron as shown in Figure 3-3. The heat will pass through the wick and melt the solder. As this happens, the wick will soak up the solder, removing it from the joint. When you're done, you can trim off the used portion of wick with your wire snips.

Figure 3-3. *Desoldering*

WARNING: The wick will get very hot, so take your hands off it as soon as you press the soldering iron to it (the soldering iron will hold it in place).

Desoldering with the Solder Sucker

The solder sucker is another tool for removing solder. It's best for removing excess solder, and you can use it to clean things up a bit before you use the wick. To use the solder sucker, press the plunger down until it locks. Use the soldering iron to melt the solder around the joint, and quickly bring the solder sucker's nozzle to the joint (Figure 3-4). Press the button on the sucker, and it will pull the solder right up into the tube. When you press the plunger again, any solder in the tube will be ejected.

Figure 3-4. *Using the solder sucker*

4/What's Next?

Now that you've learned the ins and outs of soldering, it's time to do more. You can share this book with a friend so they can learn, or you can teach them yourself. And the world is full of wonderful things you can make now that you know how to solder.

Teach the World to Solder

Before you can teach someone to solder, you need to figure out what you want them to try making. You can purchase more Learn to Solder Skill Badge Kits from *http://makershed.com*. Here are a few tips for teaching soldering to others:

Keep Your Hands Off the Tools
: You're there to teach, not to solder. And your students will learn best if they always have their hands on the tools. If you grab the tools from them and do part of the work, they won't learn from it.

Be Patient
: Try to remember what you went through the first time you tried to solder. It takes time, and you did things incorrectly, and maybe you even made mistakes that required desoldering. Let your students learn from their mistakes, and let them take their time.

No Food or Beverages
: Even with lead-free solder, there are chemicals in the flux that aren't good for you. If you allow food or drink near the work area, it could get contaminated. Keep food and drink away from where you're working.

Make Sure There's Plenty of Light
: The components you work with while you solder are small, and hard to see. Make sure to use a well-lit workspace for teaching.

Keep Spare Parts Around
: Beginners will break things. Pick up some spare resistors, LEDs, and other common components, and have them on hand in case you need to replace a damaged component.

Make More Things

Maker Shed (*http://makershed.com*) carries many electronic kits that you can apply your newly-learned soldering skills to. Here's just a few of them:

Supercap Racer Kit

One of the latest in our popular Mintronics line of DIY kits is this tiny race car designed by George Albercook. Once assembled, this little racer (Figure 4-1) will run around getting its juice from a supercapacitor. Capacitors are like little batteries. Supercaps store and release power faster than ordinary ones, so they're great for making quick-charge gadgets and power-on-demand circuits.

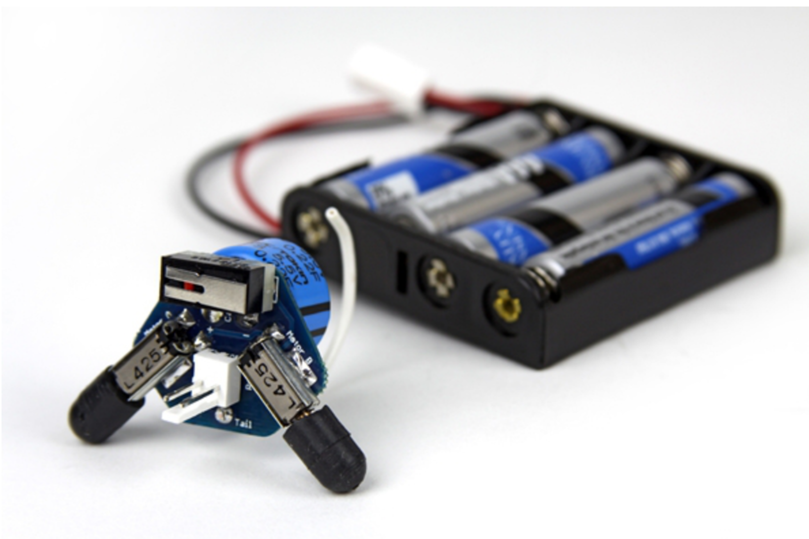


Figure 4-1. *Supercap Racer Kit*

Wee Blinky Kit

The Wee Blinky kit (Figure 4-2) is an easy-to-solder two (2) LED blinker circuit. It comes with a 9V battery snap, but will work with almost any voltage from 3V to 12V. A 9V battery is required but not included. It's tiny, it blinks, and it's a great kit to hone your soldering skills since it's cheap too!

Figure 4-2. *Wee Blinky Kit*

MintyBoost

The MintyBoost (Figure 4-3) is a small and simple USB charger for your iPod or other MP3 player, your camera, cellphone, and any other gadget you can plug into a USB port to charge.

Figure 4-3. *MintyBoost USB Charger Kit*

About the Authors

Brian Jepson is an O'Reilly editor, hacker, and co-organizer of Providence Geeks and the Rhode Island Mini Maker Faire. He's also been involved in various ways over the years with AS220, a non-profit arts center in Providence, Rhode Island. AS220 gives Rhode Island artists uncensored and unjuried forums for their work and also provides galleries, performance space, fabrication facilities, and live/work space.

Tyler Moskowite, a programmer, engineering intern at Make Magazine, and student at Santa Rosa Junior College, has been tinkering with electronics for almost half his life. He picked up Arduino, then Android, and with the release of the ADK he has found his niche.

As a photographer for Make Magazine, Gregory Hayes has ruined more clothes than he ever did as a handyman, hiked more miles with a heavier load than he did as a backpacker, done more research than he did as a writer, and gotten closer to more human hands than advised by any epidemiologist. Taught to solder at the age of seven and forced to solder for his supper at the age of nine, he's now content to let others enjoy the lion's share while he stands by watching safely from behind glass.

How to solder

This pdf refers on informations from the site: http://store.curiousinventor.com/guides/
Have also a look to the 7min. Tutorial video on: http://store.curiousinventor.com/guides/How_to_Solder

Select a Soldering Iron

A 25 or 30 Watt iron should suffice for most small electronics work.

1. Most **soldering "guns" are vastly overpowered for electronics soldering** and can easily overheat components or expose them to harmful voltages. However, some people cleverly use them to solder multiple leads on surface mount devices. Soldering "guns" are for plumbing and much heavier duty applications, and are usually over 100 Watts. The "guns" work by passing high currents through the tips, and these currents can generate voltages that damage electronic components. Also, magnetic fields from guns with transformers can damage some electronics.By forming the heating element in the shape of of the chip, a soldering gun can be used to heat many leads simultaneously.

2. **How much wattage do you need for a particular application and how does wattage relate to tip temperature?**

   A loose analogy: Imagine a car tire has a leak, but you're trying to keep it inflated by pumping air into the tire at the same time it's escaping out the leak. The bigger the leak, the more air you have to pump into it to keep the pressure up. If the tire pressure represents tip temperature and the air lost through the leak represents heat lost through the tip, then wattage represents the maximum amount of air your pump could supply. Once more air escapes through the leak than your pump can replace, the tire pressure (or tip temperature) starts to drop.

   If you had a very small leak and a huge pump (say a 100 Watt iron equivalent), you might be afraid that the pump would cause the tire to explode since so much more air is going in and so little going out. But if you have a nozzle to regulate the pump's air, you could only allow just the right amount of air in to replace what's lost through the leak. This is how "temperature controlled" soldering irons work. As long as you aren't losing more heat out of the tip than the iron can replace (up to its rated wattage), it will automatically regulate just the right amount of heat into the tip to maintain the same temperature.

   However, typical plug-in irons have no such regulation. A 15 Watt iron always delivers 15 Watts of heat to the tip, and the tip temperature stops increasing only when 15 Watts of heat escape through the air. When the tip touches a part, its temperature drops, and if the part you're soldering can dissipate enough heat, the temperature will keep dropping until it won't melt solder any more. After the iron is pulled away from the joint, the temperature will climb again. There is some amount of natural regulation: as the tip gets hotter, it dissipates more heat, and as it gets cooler, it dissipates less.

   Usually, the bigger the component the more heat it can absorb and dissipate, so the general rule is that you need more wattage for larger parts. If you're just soldering small resistors and ICs, 15 Watts will probably suffice, but you may have to wait a bit in between joints for the tip to recover. If you're soldering larger components, especially ones with heat sinks (like voltage regulators), or doing a lot of soldering, you'll probably want a 25 or 30 Watt iron. For soldering larger things like 10 gauge copper wire, motor casings, or large heat sinks, you may need upwards of a 50 Watt iron or more. The following video shows what happens to tip temperature as 15, 25, and 40 Watt irons solder various sizes of wires and components. For cheap irons, higher wattage does indeed mean higher temperatures!

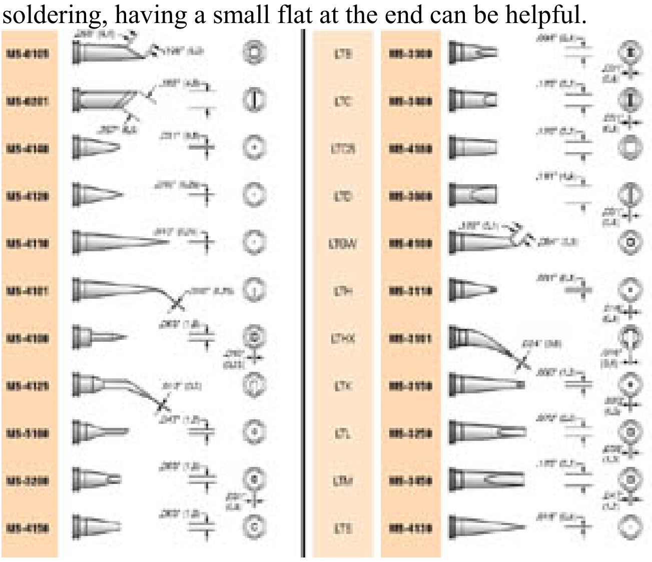
- What is the difference between cheap RadioShack® irons and more expensive ones like Wellers®? What do $100+ and $400+ soldering "stations" have over the cheaper kinds that plug straight into the wall? expand Among the irons that plug straight into a wall and don't have a separate station, the dirt cheap kinds will work satisfactorily for many applications. From personal experience, the tips on RadioShack® irons often come loose and sometimes can be impossible to remove. The irons can also get uncomfortably hot to hold after several hours of use. The more professional Weller (or other) lines are made for longer, continuous use and have insulation on the handles that keeps them cooler. They

can also take a wider variety of tips.
Soldering iron "stations" usually provide some control over the heat being supplied to the iron tip. Ones that are temperature controlled automatically control the amount of heat delivered to the tip so that it remains at a set temperature. In every iron, when the tip touches a component, some heat is lost and the temperature drops. One measure of quality is the time needed for the tip to regain its temperature. A nice feature of many soldering stations is that the tip heats up in seconds after you turn it on.
Many stations also allow you to hot-swap the iron tip, which can be very helpful if you're alternating between surface mount joints and larger components.

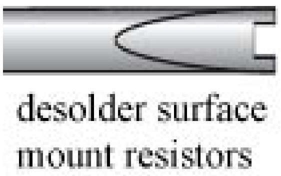
- If standard tin-lead solder melts below 400 °F (and lead free below 500 °F), why do most soldering irons have tip temperatures between 600 and 800 °F? Just what is the right **soldering temperature**?
  expand The basic reason that tips are so much hotter than solder's melting point is because that difference helps to transfer heat faster to the joint. What is the "correct" temperature is a debatable topic, but a common rule of thumb is to start off at 600 °F and increase from there until acceptable results are achieved. Typical Kester (a solder manufacturer) datasheets recommend 600-700 °F for lead-based solder, and 700-800 °F for lead-free solder. "No-clean" or "low solids" fluxes will burn off before a joint can be made with higher temperatures, so low temperatures (below 700) may be essential for these fluxes.
  From Kester's hand-soldering knowledge base: "When hand soldering with a rosin flux such as the Kester #44 or the # 285 the recommended iron tip temperature is 750°F. If you are soldering with a low residue no clean solder such as the #245or # 275 we recommend a tip temperature of 600-650°F.
  What are acceptable results? The goal is to heat up the parts enough so that solder will adhere to them and form a good bond. The higher the iron temperature, the faster it will heat up the parts, so why not set it extremely high to work faster?
  Besides the obvious increased risk of overheating components and the board, higher temperatures cause the iron tip to oxidize faster and can significantly reduce its life. Some claim a 10 °C rise reduces tip life by half (ref p.33). For occasional use, though, tip life may not be much of a factor, especially if the tip is kept covered with solder at all times.

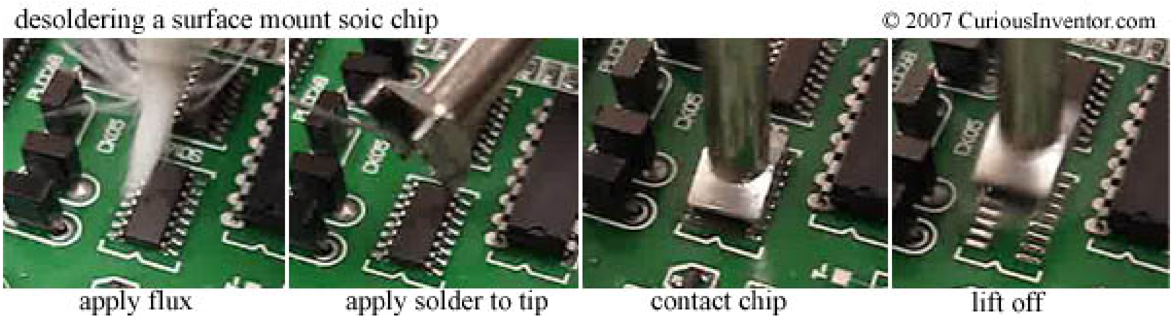
- **Tip size and shape:** a basic guide is to pick a tip that's slightly smaller than the pad you're soldering to. From there, you want a tip with a large thermal mass and short stroke (why?) In most soldering irons, the tip is not actually the heater, but sits in between your work and the heater. You can think of it like a heat bucket that empties into your work and gets filled again by the heater. Typically touching a component empties heat out of the tip much faster than the iron can replace it, and if you have a small bucket (tip), the temperature will quickly drop to an ineffective level.
  Especially if you have a small wattage iron (15 Watts or less), the temperature will drop before you can heat up a larger part, or you'll have to wait a bit in between joints for the tip temperature to recover. With a bigger bucket (tip), you can handle larger joints with smaller wattage, but eventually you'll need to step up the wattage.
  The "stroke", or length of the tip should be minimized to get the heater closer to the work; it takes some time for heat to transfer through the tip. This is balanced with the need to get into tight places where you need a longer tip.
- What do common tip shapes look like and what applications are they best for?

Screwdriver, spade, and conical are some of the more common tip shapes. Personal preference is the biggest factor when choosing a tip, but the goal is to get as much surface area contact between the tip and work as possible. Chisel and spade tips have more surface area at their ends, and also "hold" solder at their tips more readily than conical tips, which have a tendency to draw solder away. Even for fine pitch surface mount soldering, having a small flat at the end can be helpful.



- There are myriad other tip shapes and sizes. The picture to the right shows one Plato catalog page of many. Some other non-standard shapes include a knife-blade (useful for fine pitch leads) and a surface mount desoldering tip.

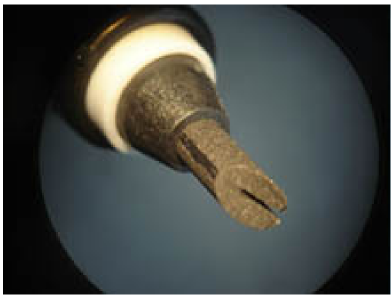




To preserve tip life, the number one thing you can do is reduce the tip temperature (if your iron allows this). After that, ALWAYS keep a layer of solder on the tip to prevent the tip itself from oxidizing, and clean it in between uses. Put a glob of solder whenever you put it back in the stand, and before you turn it off. When heating up a new tip for the first time, hold solder against it so the tip can be covered as soon as the iron gets hot enough.
The longer flux residues and oxides are left on the tip, the harder they are to clean off. They also can drastically reduce the tip's ability to heat up a part, and prevent solder from "wetting" the tip. Regular cleaning of the tip before use is one of the best ways to prolong tip life and make soldering easier. It's important that solder "wet" or cling to the surface of the iron--without solder in between the tip and work the tip's ability to heat is drastically reduced.

- What about gas powered irons and the Cold Heat® iron that is supposedly touchable 1 sec. after use? Butane (and other gas) powered irons are mainly used in situations where electrical power isn't

available. Weller sells some battery powered irons as well.
Everyday Practical Electronics gives a pretty damning review of the Cold Heat iron here, in addition to having one of the better how-to guides out there. To summarize, the Cold Heat® iron has a forked end that you must bridge with the work or solder to turn on the iron, so it can be hard to hold it in a place that keeps it on and also effectively heats the part. Many people complain about pushing harder to make a good connection and then having the brittle tips break. Running power through your work to heat it may not be the greatest idea with some parts. Finally, the iron doesn't get hot enough for a lot of jobs, or cool enough to do anything like throwing it in your pocket right after use. But for something that's portable and cordless, heats up and down in under a few seconds, maybe it's worth the price ($20). Weller's battery powered ($20) iron doesn't have a forked end and supposedly heats up in under 15 seconds, but I don't know about cool-down time.



What kind of solder (rosin cored, etc. lead-free)? What is flux and when is it necessary?

As a starting place, for most small electronics soldering, 1/32 inch (.03) rosin-cored, 60/40 (tin-lead) or 63/37 solder should work fine. Rosin-cored lead-free is fine, too. Unless you have reason otherwise, don't use "no-clean" solder--it's very likely that you don't need to clean the regular rosin-cored solder. The solder should be thin enough to prevent accidentally applying too much (and causing a solder bridge), but thick enough so that more doesn't have to be gathered from the coil too often.

Besides affecting your feed-rate and convenience, the solder thickness also relates to the amount of flux that is delivered. Flux is basically a weak acid that removes oxides so that solder can adhere to the metal, and is so essential to the soldering process that it's built into the core of common wire-solder. It also helps the solder spread out (reduces surface tension), transfer heat, and acts as a protective blanket to keep oxygen away from the metal until solder displaces it.

For the most part, manufacturers include a sufficient amount of flux in the wire, but if you use an extremely thin wire there may not be enough to clean the joint OR the iron tip. Consider using a thicker gauge for cleaning the tip periodically if you're using especially thin solder. Liquid flux is helpful for SMD soldering, too.

When picking a wire-solder, there are 4 features to decide on: flux type and amount (% weight), alloy (tin-lead, lead free, silver bearing, etc.), thickness and total amount (1oz, 1lb?).

- **Flux:** Just what is flux, what kinds are there, and when do I need liquid flux?

  Why it's needed: Solder doesn't just freeze on a joint, it actually forms a metallurgical bond by dissolving and chemically reacting with the base material. Unfortunately, almost all metals oxidize in air and form an oxidized layer that prevents solder from wetting and bonding to them. What is oxidation?

  Oxidation, is when Oxygen (or other oxidizing agents like sulfur) atoms combine with base materials, stripping loosely attached electrons and forming new compounds like iron(III) oxide. It is what happens when apple slices turn brown, iron rusts, copper turns black / green and unsolderable. (read references for more accurate/complete explanation)

  Results vary significantly. When iron rusts, the oxides flake off until no iron is left. Alternatively, aluminum oxidizes extremely rapidly, but is then protected from additional oxidation by the oxide layer. This layer makes Al impossible to solder without using special solder and extremely aggressive flux, or plating the surface with a solderable metal, like nickel. The chromium in stainless steel fulfills the same function, oxidizing to form a protective barrier that is difficult to solder. Gold remains shiny

because it doesn't oxidize, and is easy to solder to, but forms brittle joints. Heat, moisture, and salt all increase the rate of oxidation.

Oxidation can add a hidden cost to components and boards that may have been sitting on the shelf for long periods of time, or have been exposed to hot, humid environments. Copper pads on PCBs (printed circuit boards) are covered with solder or are plated to prevent oxidation, but given enough time, oxygen can still penetrate these barriers. Surplus parts in particular may need a bit of steel wool.

Some interesting references:
rusting chemical reaction
fairly understandable explanation of oxidation
wiki/Corrosion
wiki/Oxidation

Oxidation occurs much faster at higher temperatures, so even if you somehow had clean metals to start with, you would still need flux to prevent new oxides from forming while soldering.

The main choice to make when deciding on a flux, whether it comes in a cored wire or a liquid or paste form, is how aggressive it should be. The more aggressive or "active" the flux, the harder the oxides it can remove, and the faster it can remove them. Going from weakest to strongest, typical choices for hand soldering applications include: "no clean", RMA (Rosin Mildly Activated), RA (Rosin Activated), and water soluble. A newer classification system (J-STD-004) has recently been adopted and classifies fluxes not by rosin content, but by activity, material, and halide presence.

The new system classifies flux by material (RO=rosin, RE=resin, OR=organic, IN=inorganic), activity level (Low, Moderate, High), and halide presence (0 or 1). No-clean, rosin-based no-clean fluxes might be labeled ROL0 or ROL1. Although there is no direct translation between the old system and new, most R and RMA fluxes fall under Low activity level, RA are generally labeled as Moderate activity, and water soluble are High activity. (source IPC-HDBK-001 www.ipc.org)

The downside to choosing a more aggressive flux is that the residues left over after soldering MAY be corrosive, conductive, or enable fern-like growths called "dendrites" to grow between connections. A brief description (p.29) of dendrite growth and some great pictures at the end of this paper.

Because of the risk of corrosion and dendrite growth, most manufacturers clean off the residue from RMA and RA fluxes, and some even clean "no-clean" residues. The question of what flux to use and whether / how to clean it is quite involved.

Rosin flux is quite an interesting animal. Made from pine tree sap, at room temperature, it's an excellent insulator and non-corrosive. When it hits 226 °F it begins to turn acidic and attack oxides, but then when it cools it supposedly leaves residues that are again inert. Kester's data sheet for "44" flux (classified as RA and ROM1) claims no cleaning whatsoever is necessary. I haven't read of any manufacturers that would use a RA (or even an RMA) flux and not clean it--the military won't even use a RA flux WITH cleaning because of the risk that some will be left behind. This Chemtronics author recommends cleaning even the "no-clean" fluxes. He also points out that even if the residue is non-corrosive and non-conductive, it might be tacky and attract dust that causes a short.

To add one more piece to the puzzle, flux generally gets used up during the soldering process. This is why no-clean fluxes are oftentimes ineffectual for lead-free soldering, which can require slightly higher temperatures and longer heating because the lead-free solder "wets" slower. The no-clean flux can burn off before the joint is complete. Alternatively, if you apply liquid flux far from a joint, it may still be active (corrosive) if it never got heated.

I'm not making missile guidance electronics, I'm making a robot that pours a beer, what flux should I use and do I really need to clean? Even manufacturers of non-life critical electronics have much more stringent reliability requirements than an individual. They must ensure that tens of thousands of products will work for multiple years, not a single project.

The safe advice is to use the least aggressive flux that enables solder to quickly wet or cling to the surfaces, and then clean off the residues with alcohol and lint-free wipes (don't just spread the flux around). Try starting with a rosin-based mildly activated flux: RMA. I am inclined to trust Kester's spec sheet for "44" (RA) flux that says it does not actually require cleaning. Other flux manufacturers may have RA or RMA level fluxes that do indeed need to be cleaned, so if you don't know what you're using, cleaning is probably prudent. If you are going to clean rosin fluxes, do it soon after soldering because they quickly harden (see pics under 'Cleaning'). Finally, I would personally avoid no-clean fluxes and solder unless you have a critical application and very clean parts.

Lead-free solder generally requires a made-for-lead-free flux designed to be used under slightly higher temperatures.

Liquid flux can greatly help with surface mount soldering and desoldering components, but the flux inside cored-solder should be sufficient for through hole components. When soldering SMD components and desoldering pretty much anything, liquid flux acts as a blanket that helps to spread heat and also keep oxygen away from the metals. Finally, flux lowers the surface tension of solder, helping it to spread out and wick into connections.

A water-soluble flux may be necessary for heavily oxidized parts or difficult metals like nickel. Without question, clean these fluxes. Special fluxes and solders exist for aluminum and stainless steel and these also certainly require cleaning. Never use acid-core solder; it deposits zinc chloride into the solder that cannot be cleaned out. A final reason to clean flux residues is if you'd like to apply a conformal coating and aren't sure whether it will adhere to those residues.

Some more references:

- Never use acid-core and how to solder to stainless steel (Kester)
- White residue and all about rosin (more Kester)
- Good mini-class on fluxes: Bolton University
- To clean or not to clean and a brief history of electronics cleaning: more Bolton
- The Kester catalog provides good info on the solderability and flux requirements of various materials (see p.14).
- Flux residues and what to do about them. This explains a bit about cleaning options and the health risks of rosin and non-rosin fluxes.

- **Alloy:** 60/40, 63/37, tin-lead, lead-free, silver bearing, RoHS, eutectic, oh my...

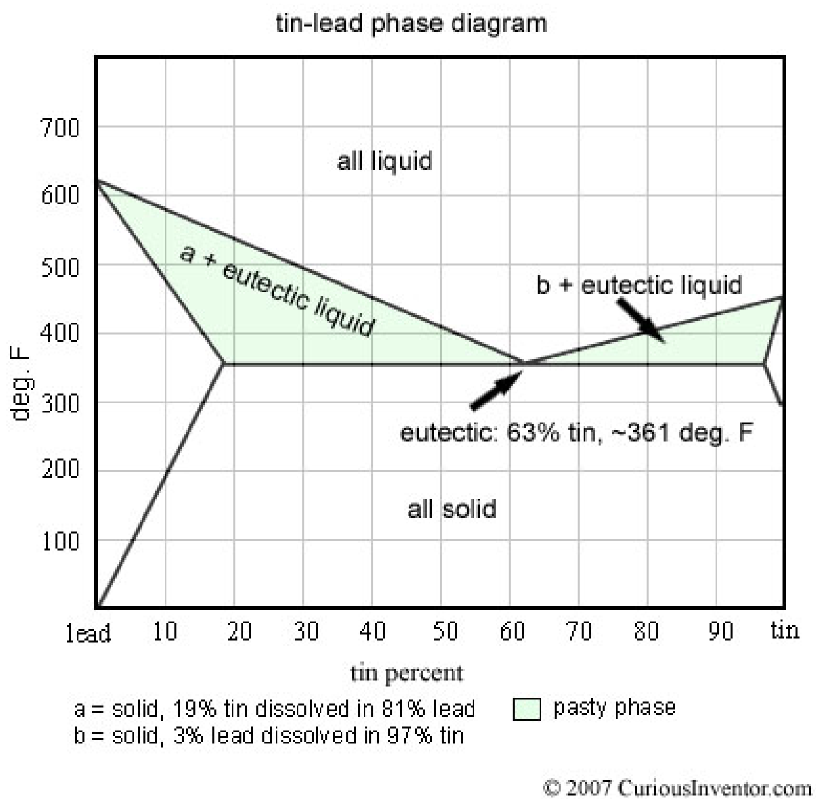
- **Standard lead-based solder** is made of tin and lead. When you see 60/40 or 63/37, it means 60% tin by weight, 40% lead. Either once of these alloys should be fine for typical small electronics soldering. 63/37 in bulk is slightly more expensive because of additional tin, but has the special property of being a "eutectic" alloy, which transitions from liquid to solid at one temperature (like water) instead of range of temperatures. Basically, in non-eutectic alloys like 60/40, there is a "pasty" region of temperature where portions of the solder are frozen and other portions are liquid. What does this mean for soldering and is 63/37 really that much better?

  Alloy metals have some interesting properties that are different from the metals comprising them. In tin-lead solder, the mixture has a lower melting point than either lead or tin alone, and the melting point varies depending on the portions. The mixture that yields the lowest melting point is called eutectic. This is also the only mix where all the constituents melt and freeze at the same temperature.

  If the tin-lead alloy isn't eutectic (ie, if it is not 63% tin), it will go through a "pasty" phase while it freezes. Unlike water, which freezes entirely at 0 °C, some parts of a non-eutectic mixture of tin-lead freeze at higher temperatures than other parts. For a somewhat simplified explanation, if you held the temperature of 60/40 slightly above 361 °F, the "extra lead" would solidify and be floating in a liquid 63/37 eutectic mix. For a more exact and great explanation of this process, look here.

  How is it that the mixture of two elements somehow lowers the melting point? And I quote: "increased entropy." Chew on this. (Another great phase-diagram explanation with a bonus of why ice and salt can get almost 30 °F below freezing--enough to freeze ice cream) And one last great explanation--talks a bit about grain structure and how solder isn't a simple homogeneous mixture of tin and lead.

  This compares the difference between eutectic freezing in tin-lead and eutectic freezing in more complex 3 element lead-free alloys.



So which is better, 60/40 or 63/37? A decade or so back (before the lead-free movement), most manufacturers incurred about a 5% increase in cost to switch from 60/40 to 63/37. 63/37 flows slightly easier, makes shinier joints, and has a faster total freezing time which means there is less risk the joints will be "distrubed," which is what happens when the joint moves during solidification. This can lead to internal fractures that cause poor electrical connections and unreliable mechanical joints. Note that 63/37 doesn't freeze instantly (just like water)--it still has a window of time during which the joint can be disturbed, too.

I think most would say that the enhanced properties of 63/37 really only matter for mass soldering operations like wave or reflow soldering, and that there is little difference for hand soldering. A dull joint is more often caused by insufficient heat, dirt or oxides, or lack of flux rather than alloy makeup. (A no-clean flux may burn off before the joint is complete) Holding everything else constant, the difference in shininess between 60/40 and 63/37 is completely cosmetic. If you'd like to see a shiny 60/40 joint, try using Kester 60/40 with #44 flux.

- **Silver bearing solder:** (that is, contains silver, not for roller bearings) Silver is used in one of the leading alloys for lead free solder (An96.5% Ag3.0% Cu.5%) and also as an addition to tin-lead solder, usually in the 2-4% range (when you se 62/36/2 this means Sn64Pb36Ag2).

  People claim that it flows better, has a lower melting point, is stronger, and has a higher conductivity. According to Indium's solder wire data sheet, their 2% silver solder has an electrical conductivity that is 11.9% of Cu compared to 11.5% of 63/37 tin-lead solder, a shear strength of 7540psi vs. 6200psi, and a tensile strength of 7000psi vs. 7500psi for 63/37. So, yes, the claims are true, and also mostly insignificant. Silver was initially added to solder to prevent silver platings on component leads from dissolving into the solder ("silver migration") and forming brittle joints. Having silver in the solder reduces migration, so you may want to use it on silver joints. (Note: this logic doesn't entirely make sense to me. If silver getting in the solder caused embrittlement, how does adding *more* silver prevent this?)

  Audiophiles seem to be enamored by 4% silver bearing solder, namely some from WBT, Cardas, and WonderSolder. Are these really better for audio?

  The superior claims include things like higher purity, eutectic alloys, higher conductivity, and better flux. I haven't found any controlled studies showing that a group of people can actually hear the difference, so I'm skeptical. Although additional silver does increase conductivity, the increase is small and the joint distance over which that conductivity applies is also extremely small. For what it's worth, here's a forum discussion that discusses a bit about solder in high-end audio and also a FAQ (scroll down)concerning solder on Cardas Audio's site. Another decent discussion.

  Bad joints made with any solder can create a high-resistance connection, especially if the underlying components were heavily oxidized initially. My advice: if it makes you feel better, get it, but be wary of sellers that don't provide spec sheets.

- **Lead-free Solder:** As of July 1st, 2006, European laws mandated that new electronics be almost entirely lead free. As of yet, there are no US laws (outside CA) mandating the removal of lead, but most manufacturers are switching over for competitive reasons. More on RoHS, WEEE, and lead risks:

  The European Union passed directives in 2003 stating that no equipment sold in Europe should, by July 2006, have more than .1% lead in any homogenous component (like a solder joint). The directives are known as the WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of Hazardous Substances) (wiki). There are corresponding laws in China, Korea, and California. Japan manufacturers actually voluntarily begin switching to lead

free years before RoHS or WEEE for competitive reasons. IPC's informative lead-free website: here.

Although only .5% of lead used in the US gets embedded in electronics (verses 80% in batteries), there is concern that the lead from those electronics will leach into ground water supplies from landfills. Why the concern over solder joints when batteries contain so much more lead? For the most part, lead containing batteries are recycled and regulated, whereas electronics are routinely just thrown away. The EPA claims that 1% of municipal waste is electronics. Interestingly, according to this publication by IPC, no studies have found any evidence of lead getting into the ground water from landfills.

Lead health risks: Lead does not get absorbed through the skin, and is actually not present in solder fumes to any appreciable degree (fumes are still bad for you, see fumes section below). The greatest risk of hand soldering with lead comes from ingesting lead by eating or smoking without first washing. Health risks include increased blood pressure, fertility problems, nerve disorders, muscle and joint pain, irritability, and memory or concentration problems. The latest health data indicates that there is no amount of lead that will not be detrimental to health. Google lead or start with this link.

Some great lead-free joint pictures: here.

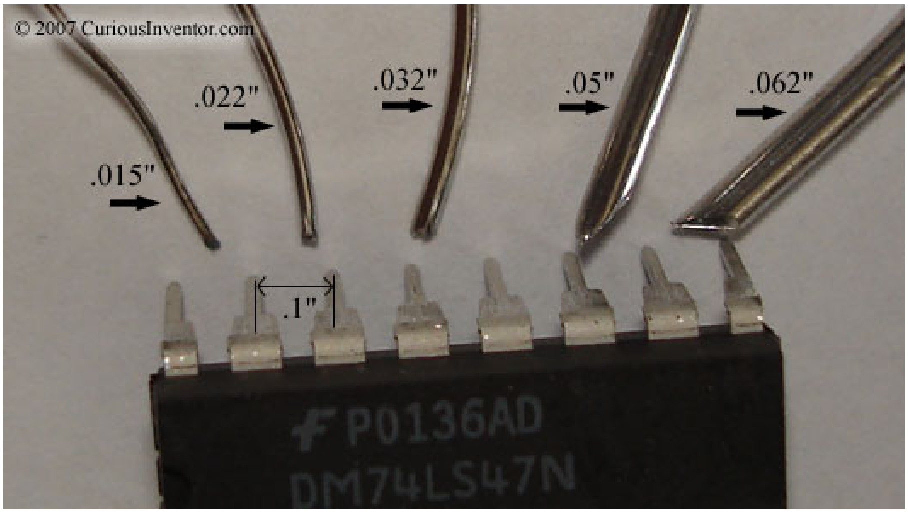
The most popular lead-free alloy seems to be Tin 96.5% Silver 3.0% Copper .5%. The wiki page on solder mentions several different lead-free varieties.
-AIM lead-free solders.
-Huge list of Indium lead-free solders and their properties.

Lead-free solder generally melts at a higher temperature, and doesn't wet as quickly to metals. (Eutectic tin-lead solder melts at 361 °F and the SnAg3Cu.5 melts at 423 °F.) Manufacturers generally recommend setting soldering iron temperatures between 700-800 °F for lead-free instead of 600-700 °F for tin-lead soldering. The 15 Watt RadioShack® iron I had operated a bit below 500 °F, so soldering should be possible with it, but maybe slow. Technique wise, since lead-free wets slower, joints will take longer (upwards of 4-7 seconds), but this doesn't mean the soldering iron temperature should be turned up excessively--patience is better than higher temperatures. If you're going to use a lead-free solder, get a flux that's designed for the higher temperatures--the regular no-clean fluxes will likely burn off before doing their job.

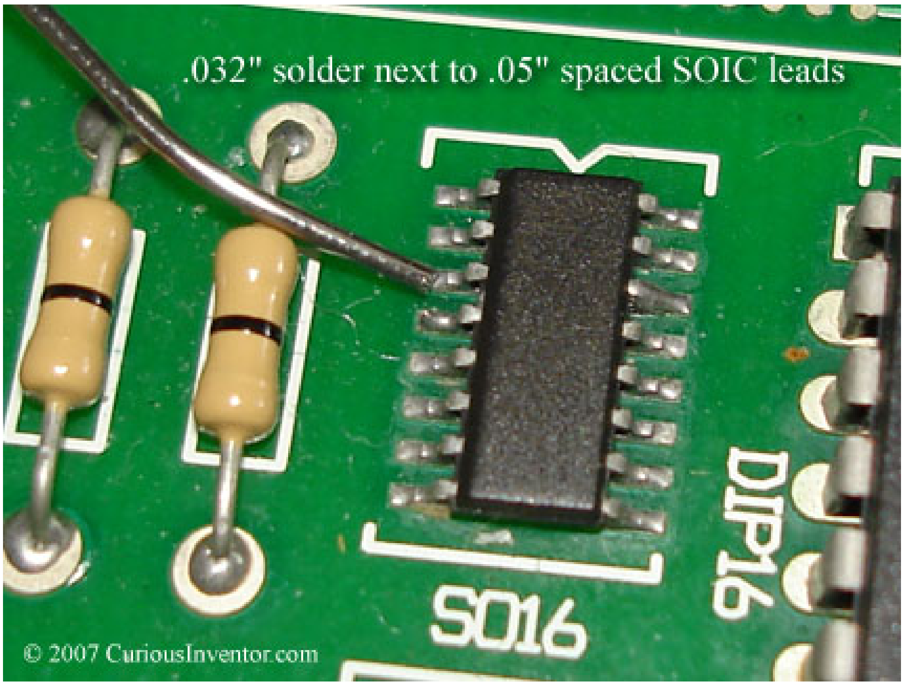
A quick word on reliability. Some say that lead-free joints are stronger, and while the material is indeed stronger, it's less flexible than lead-based solder, so expansion and contraction due to temperature change has been shown to break components held by lead-free solder. It seems true mechanical reliability of lead-free vs. lead depends heavily on the situation (see p.30). There is also concern of something called "tin whiskers." These are extremely thin crystalline growths that grow perpendicularly out from surfaces. These took down some space systems and NASA has a great page here. These are different from dendrites (which grow on the surface) and appear to be more likely on bright all-tin platings. Most component platings used to consist of a tin-lead mixture, and since all-tin platings are a common lead-free replacement, people are concerned. I have yet to find any literature that points to TinSilverCopper solder as a risk factor, though. I believe it is a plating issue, only.

One more link: -Why tin or silver?

- **Thickness and Amount:** As a general guide, .032" thick solder (21 gauge) should be suitable for through hole soldering and some surface mount soldering. For finer pitch surface mount devices, use .02" or .015", and if you're soldering a lot of switch terminals, or tinning thick gauge wire you may want .05". If you use .015" solder consider having some thicker solder on hand to re-tin your tip, since the amount of flux in .015" may not be enough to remove tip oxides. The picture below shows how the various thicknesses compare next to the standard .1" spaced DIP pins.

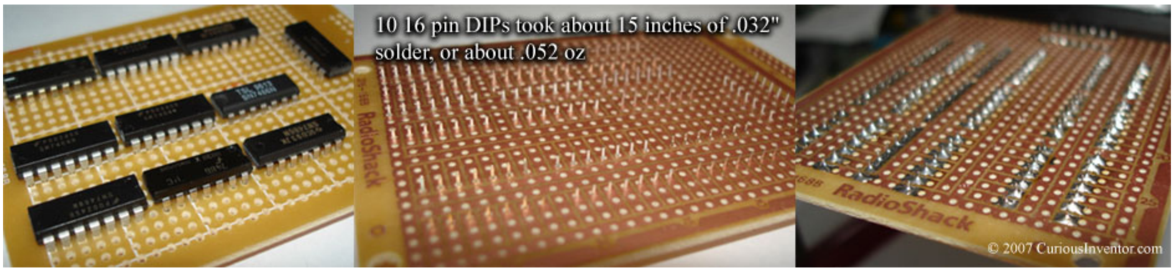


Expand to see how .032" and .015" solder compare to a SOIC surface mount chip and fine pitch (.02") device.



How much solder do I really need? An ounce? A pound? How long will a pound last?

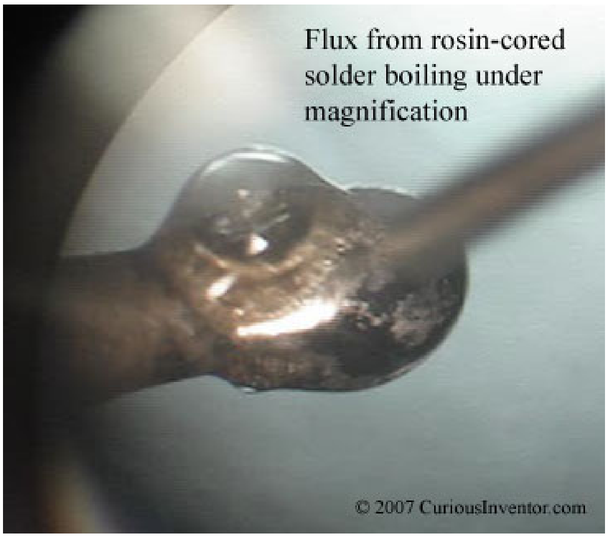
To get a very approximate feel for just how much solder is in an ounce vs. a pound, I measured how much .032" solder it took to attach ten 16 pin DIPs. Trying to provide an upper bound, the soldering is excessive, and a generous glob was placed on the tip in between each chip to account for solder used to tin and protect the tip during normal use.



The ten chips took about 15" of generously applied .032" solder that weighed in approximately at .052oz. This particular solder weighed about .00348oz/in. At about 3.27e-4 oz/joint, a 1 oz spool should last 3060 joints, a half pound should last 25 thousand joints, and a pound should last about 50 thousand joints. Mileage will certainly vary with different sized solders, joints, tinning wires, and highway vs. city driving, but if you're not in a production environment, a half pound should last a while.

Solder Fumes:

What is exactly in solder fumes? Am I safer using lead-free solder?



Lead boils at over 3000 °F, and in most cases soldering tips should be kept below 750 °F, so it is highly unlikely that gaseous lead is present in the fumes. The fumes are actually from the flux boiling, which still isn't great for you--many of the chemicals found in cigarette smoke are found in flux fumes: formaldehyde, toluene, alcohols, and hydrochloric acid to name a few. Most of the public health literature indicates that asthma is the major health risk from soldering fumes (not cancer or lead poisoning). When acquired, it is permanent and can cause hyper sensitivity so that even small amounts of fumes bring on attacks. Surprisingly, scientists have not been able to determine what exactly in the fumes cause the health defects, nor what amounts are harmful. Yet, the British health department has set exposure limits of .05 mg/m^3 over 8 hours and .15 mg/m^3 over 15 minutes. I believe these limits have been shown to provide a safe work environment and also one for which the necessary systems / filters are financially reasonable.

Some informative links:

- Solder Fumes and You A British health department pamphlet explaining the health hazards of rosin-based flux fumes (irritation, headaches, dermatitis, asthma) and what precautions employees and employers should take. Note the total lack of any mentioning of lead poisoning.
- Workplace Exposure to Rosin-based Solder Flux Fume During Hand Soldering A study done by the UK Health and Safety Laboratory measuring exposure levels and also the effectiveness of various exhaust, ventilation, and filter systems.
- Measurement of the Performance of Air Cleaners Against the Particulate Element of Rosin-based Solder Flux Fume Another UK Health study investigating the effectiveness of various fume extraction and filter systems. Most interesting finding: although activated carbon filters can remove gaseous hazards, they are largely ineffective for fine particulate in the fumes which they believe to cause much of the harm. Some combination of carbon and HEPA filter is needed, and even these are useless without sufficient air flow.

Returning to the topic of lead, it is widely agreed that eating, smoking and drinking without first washing is the greatest risk factor. Despite the high boiling point of lead, there is also agreement that at least a small amount of lead particles are indeed present in the fumes. The conspicuous lack of

emphasis on lead poisoning in all the research done by the UK health department implies that these particles are of little concern. Sentry Air Systems has a brief page that is one of the very few sources I found to claim that lead particles under normal soldering conditions are harmful. The company sells fume extraction technology.

The material safety data sheet for Kester #44 cored solder says under the fire fighting section: "Melted solder above 1000 °F will liberate toxic lead and/or antimony fumes."

According to IPC's DVD-11, "General Safety in Electronic Assembly," when solder is heated past 850 °F the lead can become atomized and end up in the fumes. video link (if link breaks, you may have to search for DVD-11 at www.ipc.org).

Useful comments from someone in the manufacturing world regarding lead.

It would seem that, for typical lead-based, rosin cored solder, the risks are probably not that great from the fumes if you only solder occasionally, don't use abnormally high temperatures, and are in a well ventilated area. If ventilation isn't too good, and you're soldering for long periods of time, the cheaper foam-type carbon filters may not be good enough.

But what about lead-free solder? Lead-free solder often requires higher temperatures and more active fluxes, and both of these factors lead to significantly worse fumes.

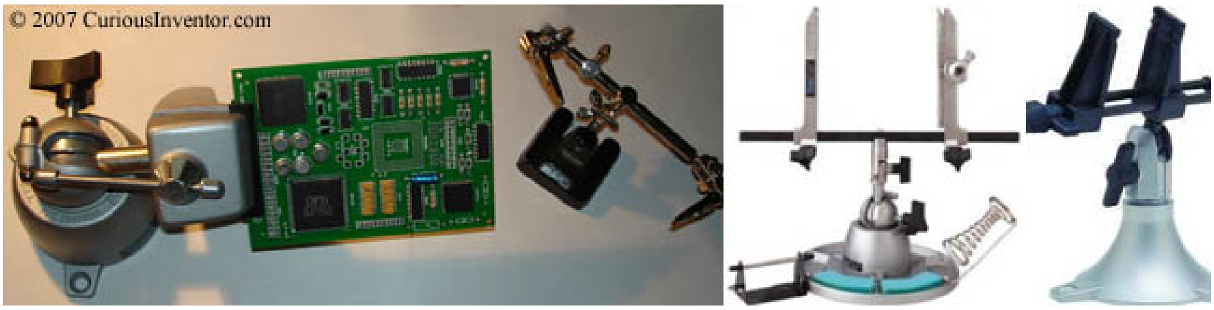
Fume Extraction Becomes More Important in a Leadfree Environment - from the Weller blog

Another excellent article on the increased risk of lead-free fumes from OK International.

Instructables has all sorts of home-made fume extractors.

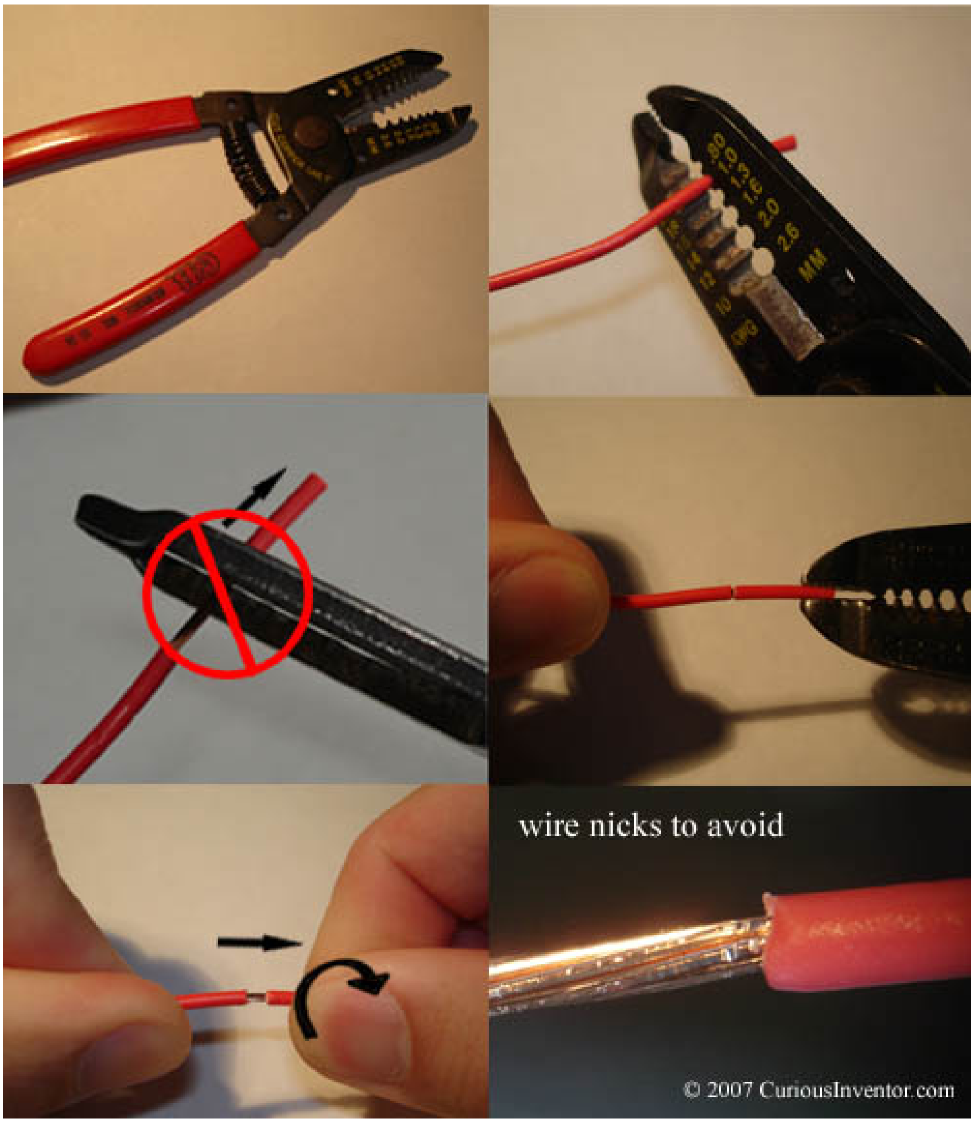
Prepare the Work

- **Start with clean components:** Flux can remove small amounts of oxides, but will be of little help for heavy oxidation, grease, oil or dirt. Notice how the solder in the adjacent picture has been repelled by the heavily oxidized pin. It may be necessary to lightly use steel wool or fine grit sand paper to remove especially bad oxides. Some people say that you should not do this because it creates scratches that can promote future oxidation... sand at your own risk. Use Silicon Carbide sandpaper (black) as opposed to Garnet (brown, for woodworking) sandpaper because the Garnet paper will shatter and become embedded in the metal. An effective and gentle alternative is to use a pink eraser, especially for copper traces.
- **Clamp your work:** PanaVise makes a popular clamp that accepts several different attachments for holding different sized circuit boards. It's by far the most popular clamp and is also very sturdy. Having the work held in place is especially helpful for desoldering when it's necessary to push or pull a bit. The alligator hands are a cheap alternative.



- **Wire preparation:** Tin stranded wires so they don't "bird-cage," or bend out from their original lay. Expand for instructions on the correct way to strip a wire manually, use an automatic stripper, and tin wire.

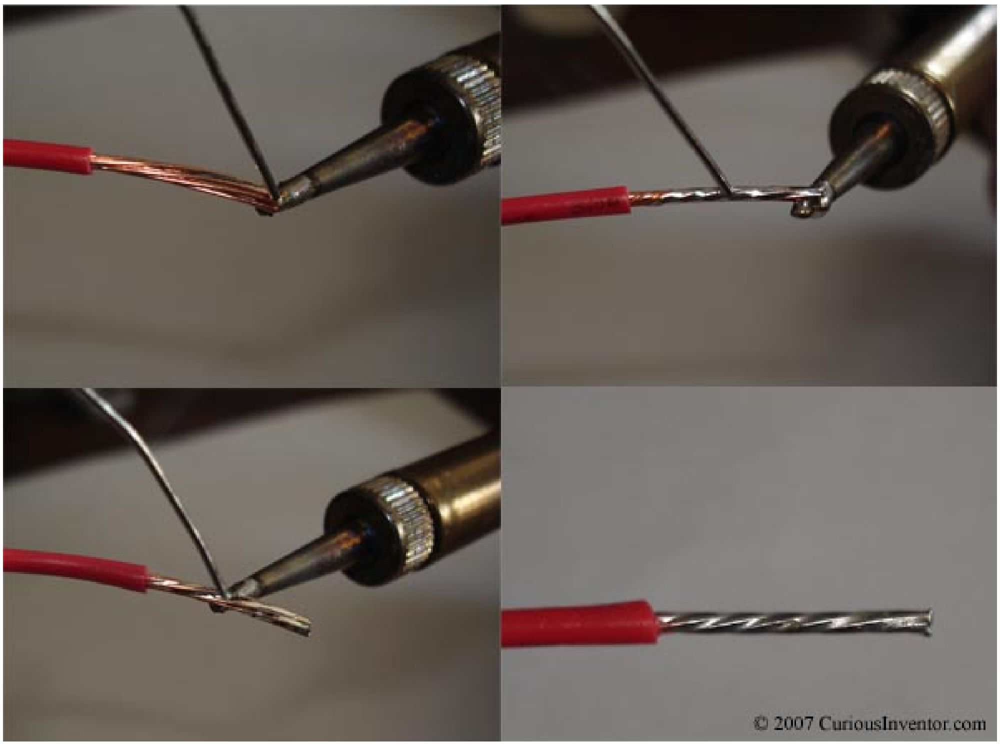
- **Manual wire stripping:** The natural way you would think to use the wire strippers is to first cut the insulation, and then use the same cutting hole to push off the insulation slug. In production environments where reliability is critical, this is not allowed because it's very easy to nick the wires this way. The pliers at the tip of the stripper are actually meant to remove the insulation slug. First score the insulation with the cutting hole, and then pull it off with either the pliers or by hand. If removing by hand, twist slightly while pulling to keep the strands in place. This is the "right" way to strip a wire, if you're careful, pulling the insulation off with the cutting hole is probably fine.



- **Automatic stripping:** With one squeeze these cut and pull off insulation.

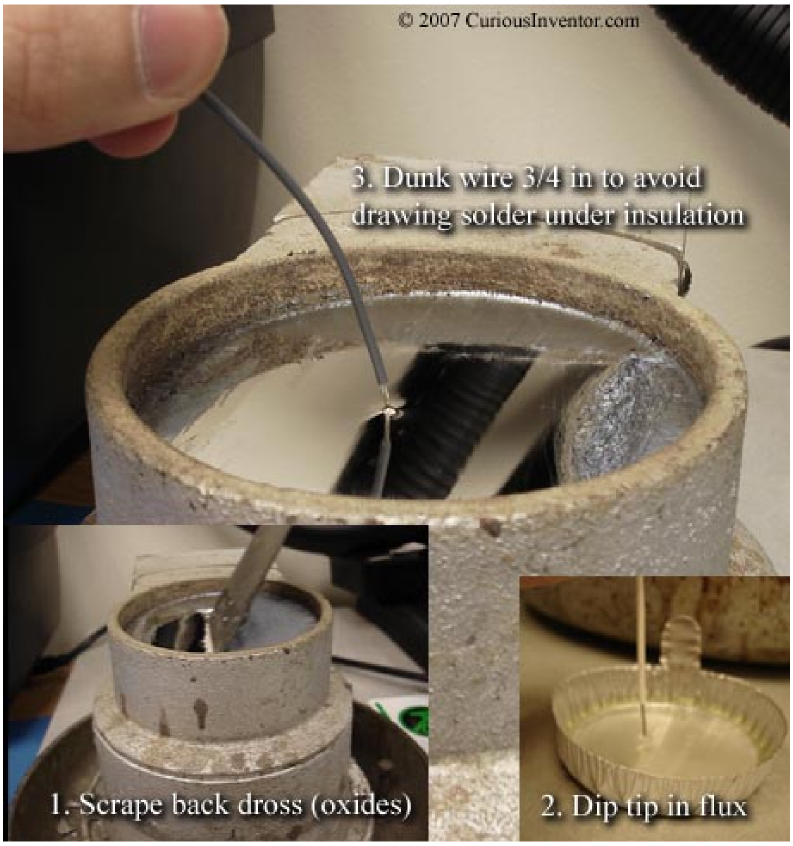
- **Tinning:** Just like soldering a joint, the key here is to apply solder to the wire, not the iron tip. If the wire is hot enough to melt the solder directly, then it's hot enough to form a good bond with the solder. Hold the iron against one side of the wire and apply a small amount of solder in between the tip and wire to form a heat bridge (if there isn't already enough solder from tinning the tip). Now apply solder to the opposite side. The solder should wick into the strands. Move the iron and solder as necessary to coat the surfaces. You should still be able to clearly see the individual strands when it's complete.

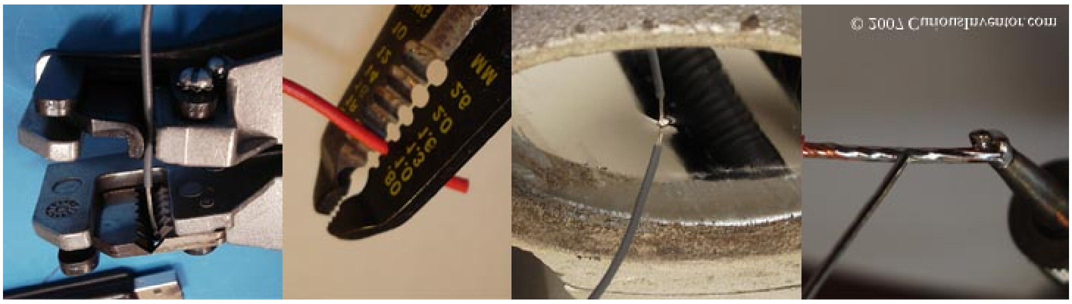
  Don't tin wires that are going to be held in clamping terminals since the solder will slowly deform under pressure and cause the connection to come loose.



Got a lot of tinning to do? For under $300 you can get a vat of molten solder to speed up the process. The only catch is that there's no flux in the vat, so you need to dip the end of the wires in liquid flux before dunking them in the molten solder. Only dip the very end of the wire in the flux; capillary action will draw it further up the strands. If you dipped more than just the

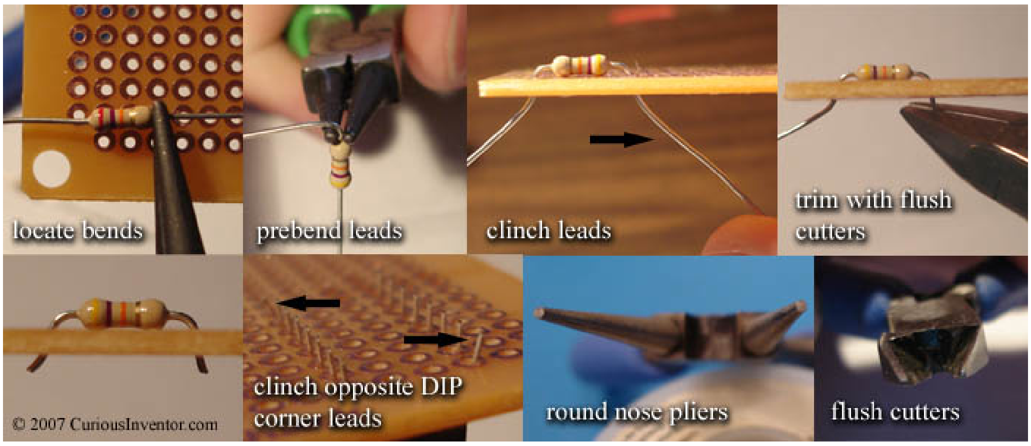
end into the flux, the capillary action would draw flux beyond the insulation where it can't be cleaned, and would eventually corrode the wire.



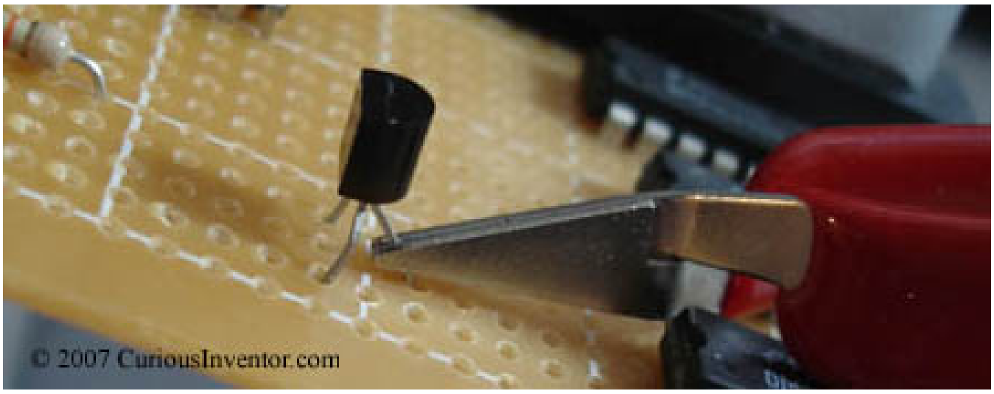


- **Insert, clinch and trim components:** First, make bends *before* inserting the components. Avoid stressing the connection between lead and component by bracing the lead with pliers while bending. Pliers with serrated tips aren't used in high-reliability production because the grooves can create nicks in the leads that eventually cause a break after a lot of vibration and thermal changes. Round nose pliers make it easy to make any sized radius.

  Unless the component has a metal casing or needs clearance for air flow to keep cool, insert it until it's flush with the board. This doesn't apply to some transistors, and also capacitors that have plastic coverings that need to be kept out of the solder joint. Clinch or bend out the leads so the component is held in place during soldering, and finally trim the leads to about the radius of the pad. Trim the leads before soldering since doing so afterwards can shock and crack the joint. Wearing safety glasses for this process is not at all excessive--those leads can get you. Everything else about proper component installation: NASA guide.



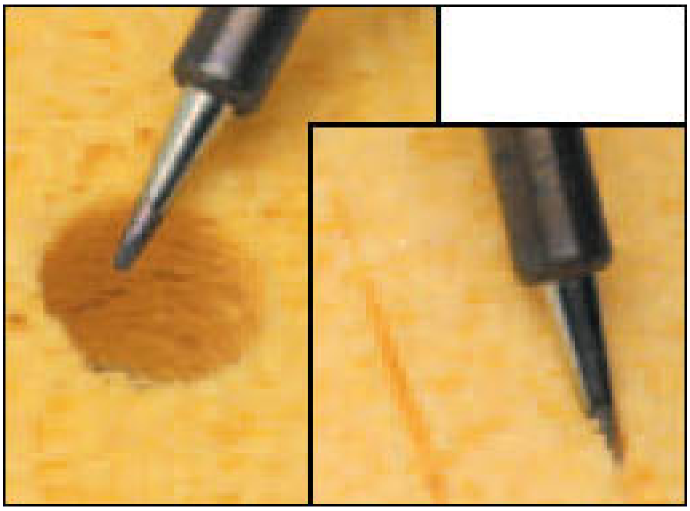
- **Add heat sink:** Some semi-conductors (some transistors and diodes) are especially heat sensitive. This clip acts a heat shunt to keep the transistor protected.



Clean and tin the Tip

· **Regular cleaning = easier soldering and longer tip life:**The iron tip's ability to transfer heat is drastically reduced when it gets covered in oxides and burnt flux residues. Not only does heat not transfer as well through this debris, but the contaminants also prevent solder from wetting or sticking to the tip. Most heat transfer actually goes through a fluid solder "heat bridge" that lies between the iron tip and components, so an iron tip that repels solder will be very ineffective.

The longer oxides and charcoaled flux residues remain on the tip, the harder they become to remove, so it's a good idea to clean the tip every time you pick up the iron.



Wiping the iron on an edge of a hole cut into a sponge can help to remove oxides easier, and also allows waste to fall away. A dry cleaner can also be used. It consists of soft metal shavings that are coated with flux. You clean by thrusting the iron into the shaving a few times. By avoiding the thermal shock of touching a damp sponge, these cleaners help to increase tip life, and in our opinion, do a better, faster job.

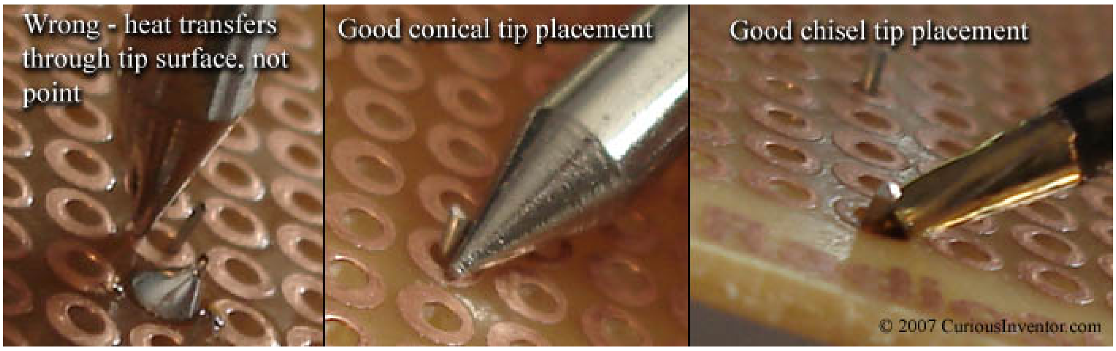
Usually touching the tip with rosin-cored solder will supply enough flux so that oxides can be removed with a damp sponge. If this isn't sufficient, you can purchase "tip tinners and cleaners" that are a mixture of solder paste and flux. The flux is oftentimes stronger (more activated) to help remove oxides.

Finally, when that doesn't work, special polishing bars to can be used to salvage extremely bad tips. Another last resort is to gently rub the oxides off with an emery cloth or soft steel brush. Cover the tip immediately with solder after cleaning to prevent further oxidation. Never file the tip to clean it or form a different shape. The tips are mostly copper with a protective iron plating, and once that plating is pierced, the tip will die quickly. Copper is used because it's an excellent heat conductor, but if exposed to solder, it will quickly dissolve into the solder.

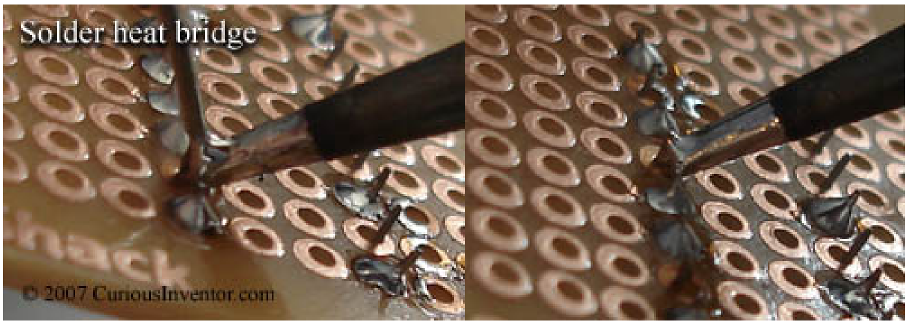
Tin the tip: Add a small amount of solder back onto the tip. This helps to protect the newly cleaned and exposed tip, and also helps to transfer heat to components.

Heat and Solder the Joint

- **Heat the joint:** Place the iron tip so that it touches both the component lead and pad--the goal is to get as much surface area contact between the iron tip and joint as possible. Almost no heat will travel through the point.

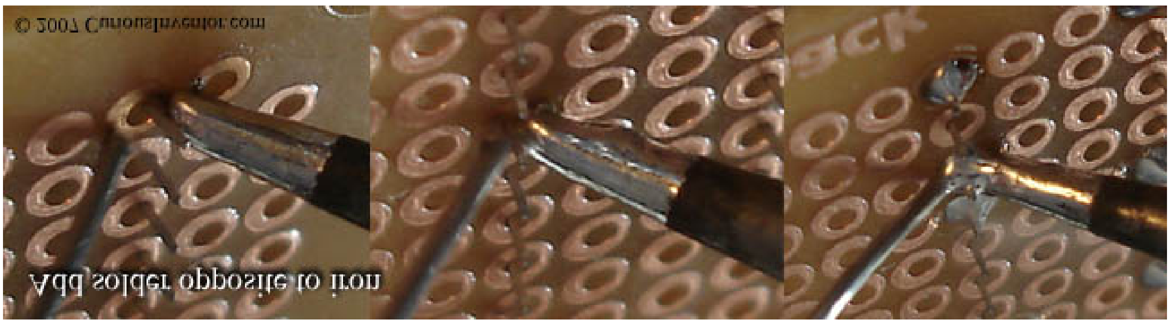


- **Make heat bridge:** Add a small amount of solder between the tip and the work--heat transfers much faster through the liquid solder than dry surface contact. This is why a tip that won't "wet" is so difficult to use. Pressing hard should not be necessary. This step may not be necessary if there's enough solder already on the tip from tinning it after cleaning.



- **Apply solder to opposite side:** Apply solder to the parts, *not* the iron. By doing this, you ensure the parts are hot enough for the solder to "wet" and bond with them. Also, solder will run towards the heat source, so applying solder opposite from the iron helps to spread it out and cover the joint.

  For larger joints, rather than dumping in all the solder quickly, continuously pulse in small amounts to keep a fresh supply of active flux available.



- **Time:** The joint should take about 2-5 seconds total time for standard 60/40, 63/37 lead based solder and a non- no-clean flux, and up to 7 seconds for lead-free solder. Lead-free solder just takes longer to "wet" the metal.

  Wetting is how easily and quickly solder spreads out over a surface. A water droplet on a freshly waxed car shows poor wetting, as does solder on a heavily oxidized soldering iron tip. It basically comes down

to how attracted the liquid molecules are to each other verses the surface (see surface tension). In industry, tests are done to determine the "solderability" of materials by measuring the time it takes solder to spread out over a surface, or measuring how much force a pot of liquid solder will pull down on a component partially submerged.

Good pictures and description of wetting and surface tension. Contains a video of a razor blade floating on the surface of water until a drop of soap is added.

A brochure for a solderabiliy testing station. Scroll down a few pages to see some great pictures of this machine holding one lead of a surface mount chip in a drop of solder.

Another related wiki: wiki/Surface_energy

In general, the goal is to make the joint as quickly as possible. Longer times can char and damage the board, lift pads, overheat components, burn off and polymerize flux (making it harder to remove), and finally lead to a more brittle joint. Solder doesn't just freeze on a joint, tin in the solder dissolves and chemically reacts with copper in the connection to form a new bonding material, called an "intermetallic layer". While this layer is what makes an excellent thermal and electrical bond, it is also extremely brittle; a doubling of its thickness reduces joint tensile strength by half (ref 1). Since this layer grows faster with higher temperatures, joints should be made using the coolest temperature and shortest soldering time possible. This layer is also why re-heating joints has been shown to weaken them. Having said all this, I have to admit that I don't know just how long is *too* long for projects that don't need to operate for 30 years with 100% reliability. After 10 seconds there's a good chance the flux has been used up.

- **Remove solder, then iron:** Pull the iron out fairly quickly to avoid leaving a solder spike.

- **Good and bad joint gallery:** The solder should smoothly ramp to meet surfaces and be shiny in appearance if it's lead-based. Lead-free solder will have a duller and grainier surface, but will still be a good joint as long as there are no signs of non-wetting. The important thing to look for is any solder that looks like it didn't cling to a surface, or is just sitting on top or next to a surface.

Gallery of joints:

A NASA gallery of every possible joint / board defect you could ever imagine. Here's another great gallery of defects.

Great comparison pictures between lead-based and lead-free joints. p. 34

Good joints:

Great joints:

What's the right amount? A large amount of solder is not needed, just enough to cover the pad and lead without any gaps (actually, only 270° is required by IPC J-STD-001). The measure for too much solder is whether or not you can see the outline of the lead in the solder. This is important because you need to be able to see whether the solder adhered or "clung" to the lead (indicating a true bond), and

didn't just freeze around it. This applies to all types of joints: tinning wires, soldering to connectors, surface mount components... the solder should never completely hide the underlying wires or leads.

Disturbed joint (bad): If the component moves during solidification, the internal structure of the solder will have fractures, leading to a high resistance or unreliable electrical connection, as well as a fragile mechanical one. The solder also appears dull and grainy--typical signs of a "cold" joint that doesn't actually bond with the underlying surfaces.

"Cold" joints are often formed when the underlying pad or lead didn't get hot enough for the solder to wet it.

Awful joints:

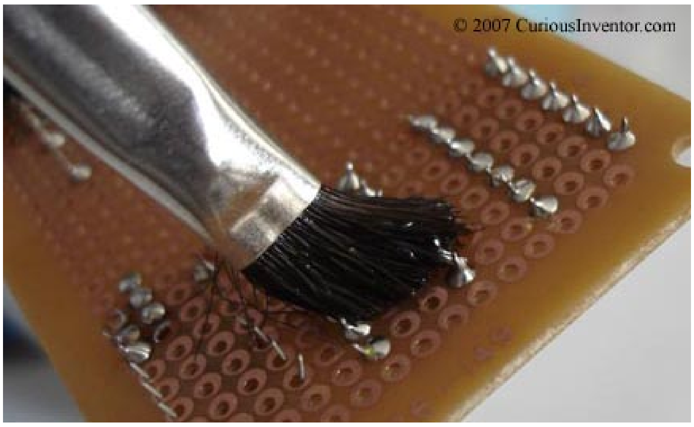

© 2007 CuriousInventor.com
Extreme over-heating
and pad lifting
No adhesion to lead--oxidized lead
Resting on and not adhering to
pad--insufficient pad heating
Solder resting on pad, not adhereing
Solder was applied to iron first and
then transfered to joint

Clean Up

Most manufacturers will clean off residues from any flux that isn't labeled "no-clean," despite flux datasheets like Kester's that say even some of the more active fluxes do not need to be cleaned. For short life-span hobby projects, it probably doesn't matter unless you're using a solder/flux labeled "organic" or "water-soluble"--these fluxes leave behind very aggressive acids that will quickly eat away circuits. Cleaning may be necessary if you're applying a protective coating that won't adhere to flux residues. Finally, some rosin residues are tacky and may attract dust that can short a circuit.

The fact that a flux is made from rosin doesn't tell you much about how strong it is or whether it should be cleaned. What matters is how concentrated the mix is and how much acidic (halides) activators were added. RadioShack® doesn't supply any information on the flux in their standard rosin-cored solder, but it's probably weak enough that the residues do not need to be cleaned off.

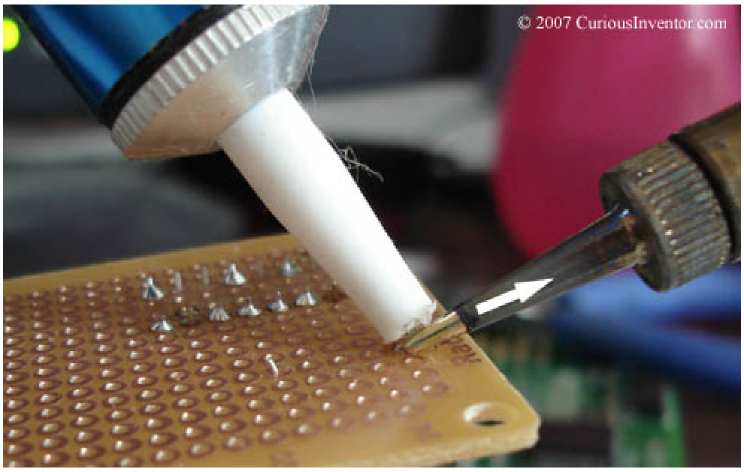
Isopropyl alcohol works decently on rosin-based residues, but clean shortly after soldering because the residues quickly harden. Use water for water-soluble fluxes. This pump containing bottle dispenses a little alcohol when you push down on the top with a brush, and keeps the rest from evaporating. If you are going to clean, make sure you wipe up the remnants with a lint-free cloth--don't just spread them around the board with a brush and alcohol.



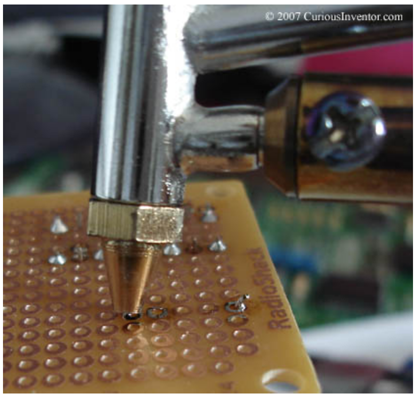
Desoldering

The three most common inexpensive ways to remove solder include a "solder sucker", solder wick, and an iron with an attached desoldering bulb.

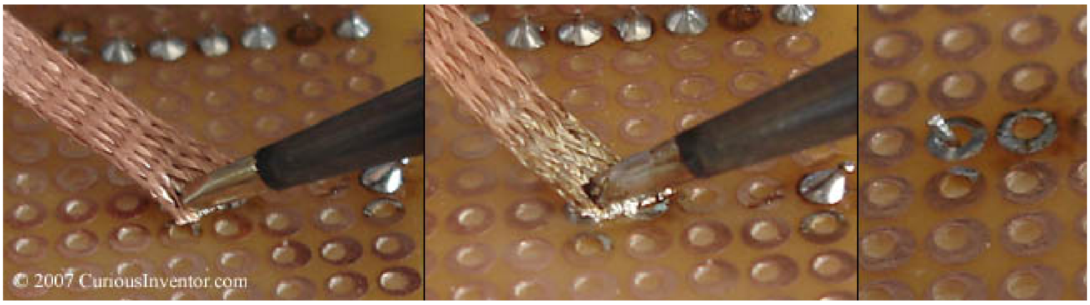
- **Solder Sucker:** To use, press in the plunger, heat up the joint, and as quickly as possible, pull out the iron, place the sucker's nozzle over the joint and press the release button. It may take a few iterations to clean out a joint enough to wiggle free a component. On plated through holes it may actually be easier to add *more* solder to the joint before sucking, since the sucker won't be able to create a vacuum with too little solder remaining.



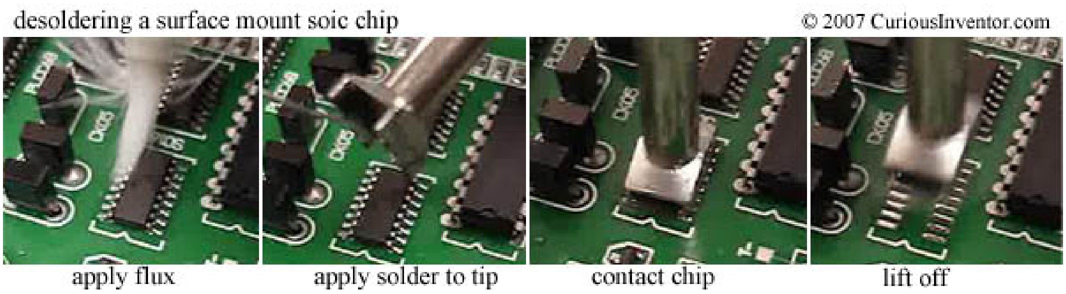
- **Desoldering Iron:** This works just like the solder sucker, but is much easier to use because there's no race to suck out the solder before it freezes, as with the "solder sucker".



- **Solder Wick (desoldering braid):** The above two tools will often not be able to completely remove all the solder. Many people use the sucker devices above to remove most of the solder, and then get the rest with solder wick, which absorbs solder through capillary action. It's a fine weave of copper wires that are coated in flux. Place it over a joint and then heat from the opposite side with a soldering iron. It may help to have a bit of solder already on the iron's tip to speed heat transfer.



Surface mount desoldering: Surface mount chips are especially hard to desolder because it's very difficult to completely remove all the solder pin by pin, and avoid overheating the board and lifting a pad. Professional shops use expensive hot air guns or special tips (shown below) to heat all the joints at once.

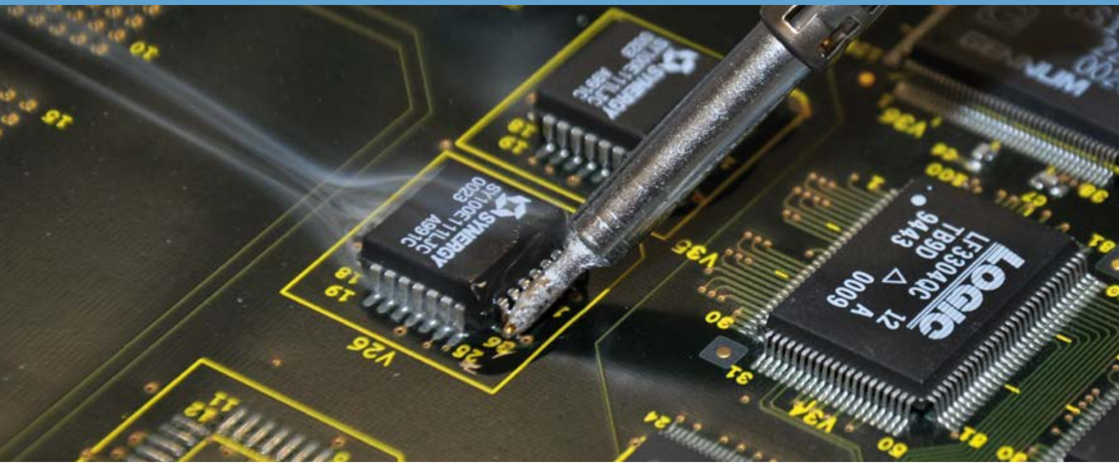


There are fortunately a few cheap ways to desolder surface mount chips.

- ChipQuik provides an interesting solder that when melted over existing joints produces a new low-melting point alloy (under 200 °F) with a much longer solidification time. The longer solidification time enables you to melt all the joints at once and then flick off the chip.
- There are many guides for making a DIY hot air gun with the RadioShack® desoldering iron and a fish tank air pump. Engadget has one of the better how-to guides. Here and here are some more plus the supposed original.

The Ersa soldering primer

Soldering made easy



kurtz ersa

Soldering – a never-ending story

for more than 5,000 years already

Man had scarcely learned how to use metals for his purposes when the desire to join them arose in him. Many of the pieces of jewelry, tools and weapons we know from the Bronze Age owe their usefulness and beauty to the art of soldering.

Today, it is difficult to say who first discovered how to "glue" metals. One thing is certain - the goldsmiths of ancient Egypt knew how to join gold and silver already more than 5,000 years ago. Their colleagues in Troy were also master craftsmen long before the ancient Teutons could even dream of such handicraft. Soldering really "came of age" when tin was discovered

as a joining metal. And that was, after all, already 4,000 years ago!

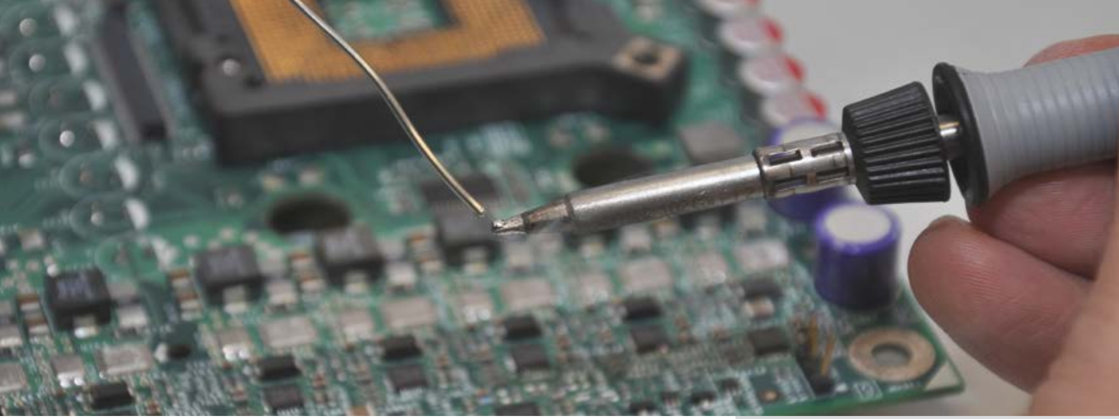
From then on, soldering technology was on its way. It first spread around the Mediterranean. The Cretans showed it to the Etruscans who then taught it to the Romans, Tunisians, Spaniards, followed by many others, including the less developed cultures of the time – the Swiss, Bohemians, Hungarians, Teutons and Scandinavians. From culture to culture, from generation to generation, the craft of soldering was continuously improved and refined.

The ancient Romans already laid down and soldered 400 km of leaden water pipes, conjured up stoves and bathtubs from bronze sheets, not to mention the excellent craftsmanship of their armorers and goldsmiths. Apart from craftsmanship in soldering, our understanding of the science of soldering has grown and has been refined over the centuries.

Today, soft soldering in the electronics industry has developed into a full-fledged production technology, encompassing the fields of mechanics, chemistry, physics and metallurgy. Ernst Sachs, the founder of Ersa (the company name consists of the initial letters of his first and last name) contributed to this development. In 1921 he developed the first electrically operated soldering iron for the industry that was manufactured in series. Since that time, Ersa has committed itself to the further development and perfection of soldering technology with great passion and extending its full power of innovation.

Today, Ersa stands for the most comprehensive product range in the soft soldering technology worldwide and for more than 90 years of industry experience and innovation, know-how and highest product quality.

The Ersa soldering iron product range covers ultra-fine soldering tips, classical soldering irons powered from the standard power net and special soldering tools up to the 550 W hammer soldering iron. Ersa's electronically temperature-controlled soldering stations represent the industry standard, as does the extensive range of rework and



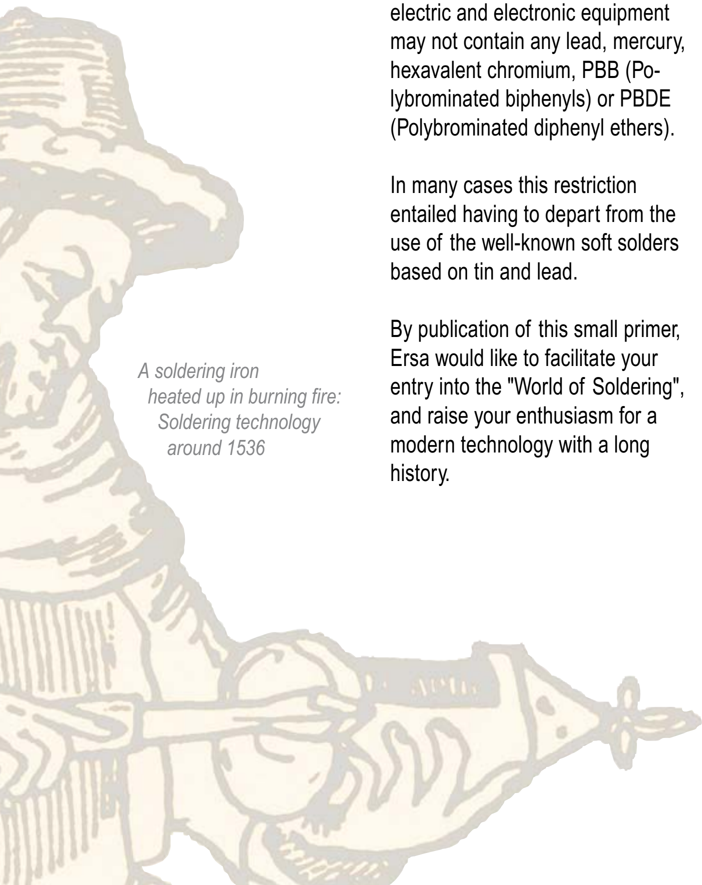
inspection systems, wave-, reflow- and selective soldering systems. The line of Ersa screen printers complements the product range.

Ersa's quality soldering tools are used in the hobby area, such as, for example, in model-making or tiffany soldering, in the craft sector, in laboratories and in industrial electronics manufacturing.

New challenges for the soldering technology were raised by the ban on certain hazardous substances (RoHS) in 2006. Since 1 July 2006 electric and electronic equipment may not contain any lead, mercury, hexavalent chromium, PBB (Polybrominated biphenyls) or PBDE (Polybrominated diphenyl ethers).

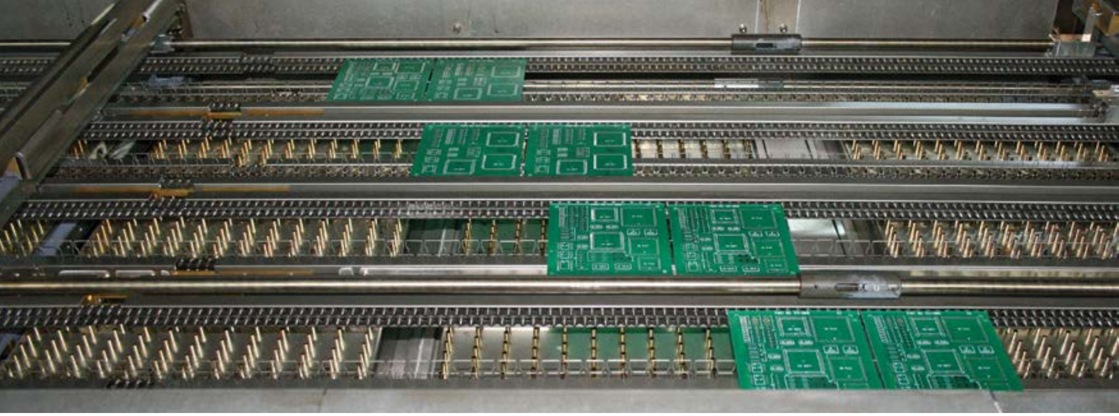
In many cases this restriction entailed having to depart from the use of the well-known soft solders based on tin and lead.

By publication of this small primer, Ersa would like to facilitate your entry into the "World of Soldering", and raise your enthusiasm for a modern technology with a long history.



A soldering iron heated up in burning fire: Soldering technology around 1536

Content



Solder joints hold the world together

Connecting pacemakers and solar parks

To imagine today's world without soft soldering is not possible. It is the means to fabricate safely functioning, electrically conducting connections. Regardless of whether we talk about power technology, drive technology, telecommunications, automation or electronic controls – in all those fields soldered connections have a decisive share that everything functions in a way as has been foreseen and planned by the developers and

visionaries of the products. Today, soft soldering is such a common place occurrence, that no one wastes any further thought on it. We take the daily use of our computers, mobile phones and play stations for granted, the modern comforts provided for by electronics found in modern automobiles is expected as a matter of course, and we fly – privately or on business – to the farthest spots in the world.

Consequential damage because of the failure of a solder joint in an iPod is relatively limited. It is a different matter altogether, though, if the electronics in an airplane full of vacationers, in a space shuttle, or in an implanted pacemaker fails.

Such failures are immanently life-threatening. But not to worry – the highest quality demands apply for those applications, and rightfully so!

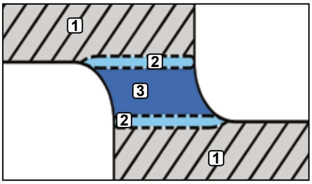
Aside from soldering in consumer electronic products, there are numerous other applications such as, to name but a few, alternative power generation with wind turbines or solar parks, R&D departments and in work performed by craftsmen such as electricians and plumbers. Let us not forget the many part-time and hobby users for whom there are no limits curtailing their phantasies and artistic freedom when handling a soldering iron and solder.

The art of soldering

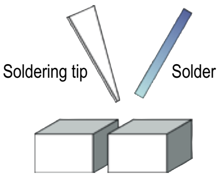
What's behind it?

In a soldering process two metal parts are joined by means of a molten metallic bonding agent (solder), whereby the melting point of the bonding agent is always lower than that of the metal parts to be joined. If the melting point is below 450 °C, then it is a soft soldering process, if it is above, it is called hard soldering or brazing. Welding, on the other hand, is the process where two metals will be heated up to their melting point, at which time they will, together with a filler material, form a pool of molten material causing coalescence. In soft soldering, the seams between the metals to be joined will be filled with a tin alloy. It is important that the alloy does not simply stick to the foreign metals' surface after cooling but unites with the metal. For this purpose, a small quantity of the foreign metals must dissolve and unite with the tin alloy forming a mix of crystals – the so called diffusion zone. That is the task of the tin, whereas the alloy's other components are responsible for the solder liquefaction and the joint's mechanical stability. A solder joint consists of the following layers:

① Base metal
② Diffusion zone
③ Solidified solder
② Diffusion zone
① Base metal

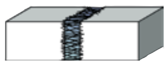


Cross section of a solder joint



The prepared parts and the solder are heated

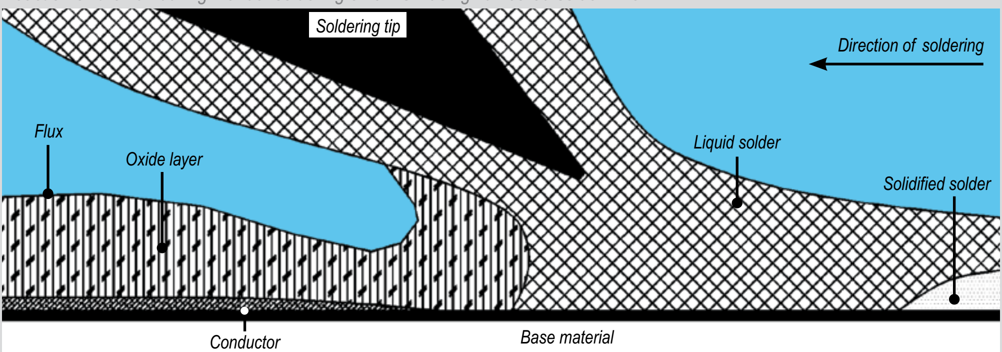
The liquid solder flows into the gap and fills it



The solidified solder joins the parts together

To achieve the highest mechanical stability, i.e. to assure the durability of the solder joint, the diffusion zone may neither be too thick nor too thin. Its ideal thickness is 0.5 µm. The formation of the diffusion zone depends on the temperature, the solder time and the alloy used. If the diffusion zone is too thick, the solder joint will be brittle and porous, whereas the formation of a zone which is too thin indicates that an insufficient connection or no mechanical connection at all has been formed.

Reaction of the flux during manual soldering on a PCB using flux cored solder wire



What do you need for soldering?

The basics – the 5 essential factors

1. The soldering iron

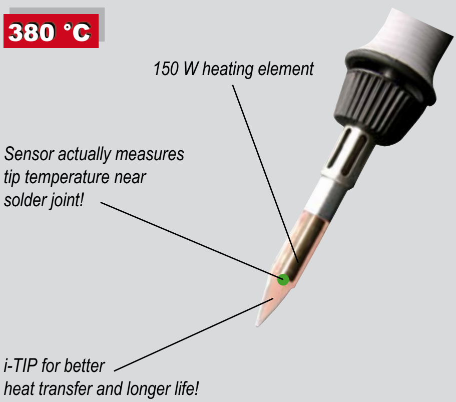
to provide the heat required

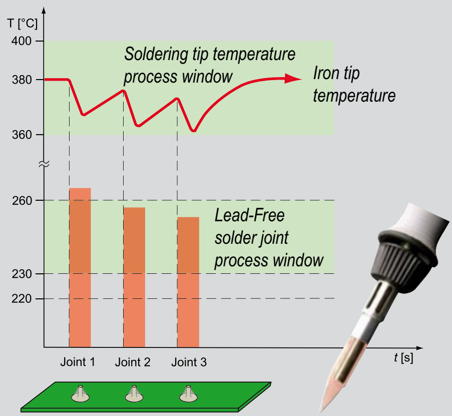
Heat is required to melt the solder. This is the soldering iron's job.

Temperatures of 200 °C – 450 °C are required depending on solder joint and solder alloy. In the field of electronics, the usual temperature lies between 250 °C and 375 °C.

In order to have the proper temperature for any soldering application, the soldering iron's thermal output and an efficient heat transfer to the solder joint to be made is decisive. One either selects a soldering iron that performs within the temperature range required, or a soldering station with temperature control is used. Temperature-controlled soldering stations enable the user to work on different applications without loss of solder joint quality, because of the precise control of the preset temperature at the soldering iron tip.

Both the soldering station's registration of the actual tip temperature should be highly precise, and the heating element should be powerful and recover quickly in order to avoid over-heated or cold solder joints.

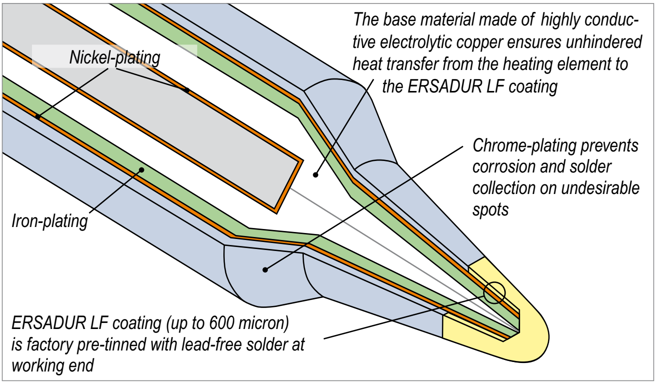




Temperature curve of controlled tip temperature when soldering multiple joints

2. The soldering tip

to transfer the heat from the heating element to the tip



Cross-section of an ERSADUR soldering tip, non-scale representation

The soldering tip is the "heart" of the soldering iron and responsible for the heat transfer from the heating element via the solder to the solder joint. Depending on the soldering iron and the application, different types of tips are available. Prerequisites for good solder joints are the correct soldering iron tip shape, perfect heat transfer, a good condition of the tip and a reliable performance over time. In addition, the soldering tip has to convey also the necessary amount of sensitivity back to the operator.

How to take solder joint quality to its peak – ERSADUR long-life soldering tips

Traditional soldering tips are made of copper which conducts heat well and is inexpensive, but the tip oxidizes heavily when heated and releases copper particles into the solder until it has been "corroded" entirely. To maintain the tip in operational shape, it requires intensive care. Today, only coated soldering tips are used in electronics production – the largest field of application for soft soldering.

ERSADUR long-life tips have been conceived for continuous operation and for high-quality results. They are galvanically plated with an iron coating and protected against corrosion and oxidation by an additional chrome layer in a very special manufacturing process, developed and used exclusively by Ersa. And their perfect thermal conductivity protects the heating element from overheating and premature wear. Ersa offers a comprehensive range of soldering tips for the diverse requirements.

Proper tip care increases tip lifetime considerably:

- Never clean the long-life tip before putting the soldering iron into its holder, since the solder remaining on the tip prevents oxidation of the solder track.
- Always keep the long-life soldering tip covered with solder, as otherwise it becomes passive and will no longer wet properly.

Passive tips can be reactivated by the application of the lead- and halogen-free Ersa TIP REACTIVATOR. All that is needed is to wipe the hot tip on the surface of the regeneration compound. Furthermore, the hot tips should regularly be cleaned with a moist viscose sponge before soldering. Alternatively the tips can be dry cleaned using the Ersa "dry sponge", a sponge made of special metal wool. Dry cleaning has proven to be advantageous in lead-free soldering. The soldering tips are not cooled abruptly, and contaminated tips resulting from dirty sponges are avoided. Due to the slightly abrasive properties of the special wire mesh, passive layers that accumulated on the tip can easily be removed. Tip life is thus increased considerably in lead-free hand soldering.

Ersa TIP REACTIVATOR. A comprehensive range of accessories is available at ***www.ersa.com***

What do you need for soldering?

The basics – the 5 essential factors

3. The solder

for the connection

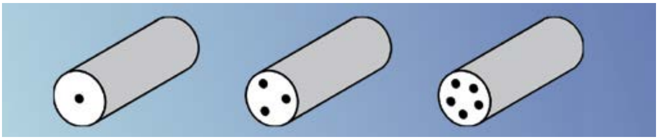
Metallic bonding agents (solders), mostly in the shape of a wire or a bar, are available as diverse alloys.

Soft solders consisted mostly of a mix of tin (Sn) and lead (Pb). Since the implementation of the RoHS directives on 01 July 2006 the use of solders containing lead is prohibited. Lead-free solders are usually alloys containing silver (Ag) and copper (Cu).

The alloy's composition determines melting temperature and physical properties of the joint. Criteria for the choice of an alloy are: production process, specification of the product, field of application, cost of the alloy.

Prerequisites for good soldering results are:

- Suitable soldering iron
- Suitable fluxes
- Clean surfaces of where to solder
- Suitable solder alloy
- Sound soldering tip
- Correct soldering time



Solder wire with one or with multiple flux cores

4. The flux

for the ability to wet

Fluxes are used to attain the best possible bonding between solder and metal. They provide for metallically clean surfaces of the parts to be soldered, remove the oxides as well as other flow-inhibiting contaminations and prevent the formation of new oxides during the soldering process. A difference is made between acidic (as used in plumbing) and acid-free products (as used in electrical and electronic applications). It is most common to use solder wire with one or more flux cores in electronics production, whereas bar solder is the form of choice in plumbing as well as in the radiator and auto body work.

Examples of some common alloys

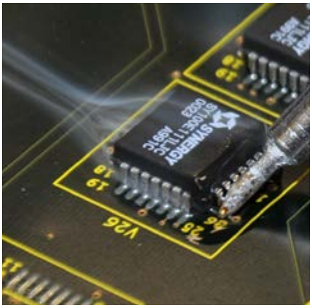
Alloy	Flux type	Melting point / range
L-Sn60Pb40	EN 29454/1.1.2 (F-SW 26/DIN 8511)	183 °C – 190 °C
L-Sn60Pb38Cu2	EN 29454/1.1.2 (F-SW 26/DIN 8511)	183 °C – 190 °C
L-Sn63Pb37	EN 29454/1.1.3 (F-SW 32/DIN 8511), free of halogen	183 °C eutectic
L-Sn62Pb36Ag2	EN 29454/1.1.3 (F-SW 32/DIN 8511), free of halogen	178 °C – 190 °C
Alloy – lead-free / complying RoHS-WEEE		
L-Sn95,5Ag3,8Cu0,7	EN 29454/1.1.2 (F-SW 26/DIN 8511)	217 °C eutectic
L-Sn96,5/Ag3,5	EN 29454/1.2.3 (F-SW 33/DIN 8511), free of halogen	221 °C eutectic
L-Sn99,3Cu0,7	EN 29454/1.2.3 (F-SW 33/DIN 8511), free of halogen	227 °C eutectic

5. A safe and clean working environment

to ensure quality and health

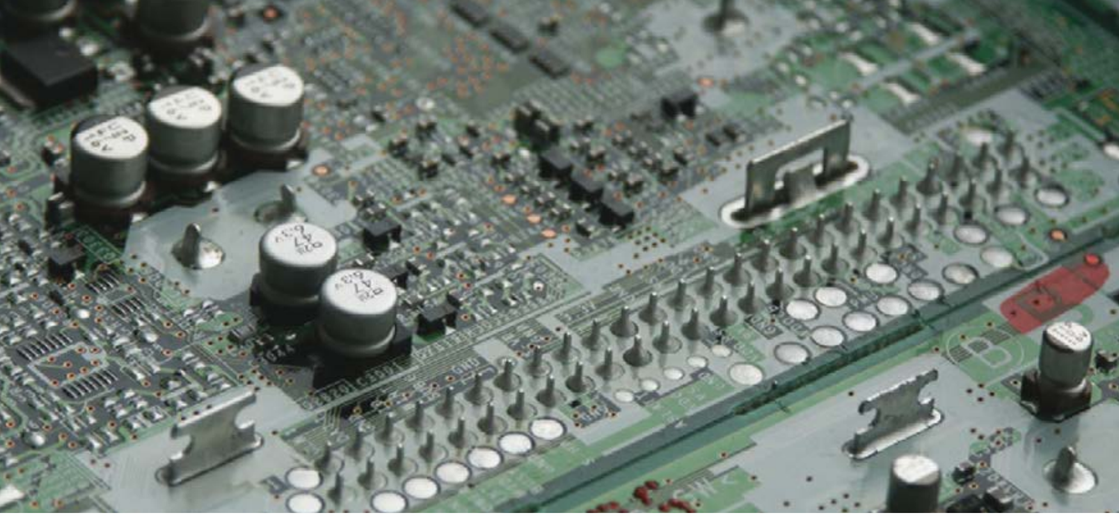
Safety first, especially while soldering. The VDE and GS emblems ensure the electrical safety of soldering equipment. The use of the VDE sign obligates the manufacturer to monitor production accordance with test guidelines and to conduct tests according to the regulations determined by the VDE testing institute.

Noxious gases develop in every soldering process



Health protection during soldering

- The breathing zone is very close to the soldering process during manual soldering, and the solder is added by hand. Thus there is the danger of contaminated air and hands or items which may have been touched
- Flux vapors can be damaging to the operator's health and should be kept out of the breathing area. Suitable devices for this purpose are solder fume extractions, which extract the smoke and associated vapors from the workplace and remove particles and gases. Modern fume extractions can be programmed to operate only when the soldering process is taking place, thus saving energy.
- One should never eat, drink or smoke in rooms where soldering is preformed. Contaminations which remain on the hands can enter the human organism through food or cigarette smoke.
- Hands should be washed thoroughly after soldering.



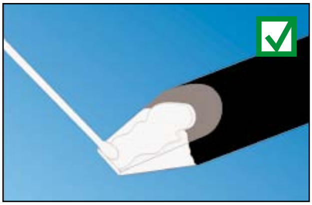
Best solder quality

due to the right preparation and correct soldering parameters

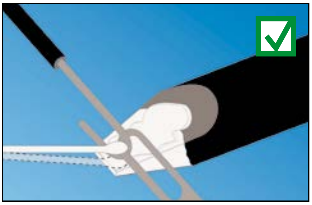
Preparation

The most important prerequisite for a good solder joint is absolute cleanliness. Conductor and component must be free of dirt, oil and oxides. They can be removed with solvents or flux.

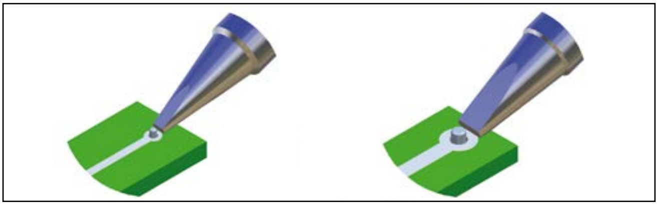
Prior to soldering ERSADUR soldering tips should be cleaned while hot with a moist sponge or with a metallic dry sponge. Do not file the tip as you would copper tips, because this would damage the protective coating and render the tip unusable.



Wetting the soldering iron tip



Soldering a joint



The selection of the right soldering tip is decisive for good soldering results

Soldering process

The soldering process has three phases: wetting, flowing, and bonding, whereas the working temperature is the most important criterion. It is best to work at the lowest temperature at which the three phases can progress smoothly. This requires some experience. A temperature-controlled soldering station will definitely facilitate this work. Place the tip on the joint to be soldered after cleaning and heat up the joint. Then feed the flux-cored solder wire between the soldering tip and the joint and melt as much solder as is required to wet the complete joint. Then remove the solder wire first and right after that the soldering tip to prevent overheating the solder. Allow the solder to solidify, avoiding any vibrations or jarring during this time.

Soldering time

The soldering process should be completed within 2 to maximum 5 seconds with a correctly dimensioned soldering tip. When soldering electronic components with lead-free solders, experience shows that more time is required. But even here requiring more than 5 seconds is not permissible, and it indicates that either the temperature setting is too low or the soldering iron lacks the necessary power.

Solder joint quality

When the leads of the components mounted on the board are crimped, a good solder joint has been formed when the contour of the soldered lead is still visible. This will not be the case, if an excessive amount of solder has been used to form the joint.

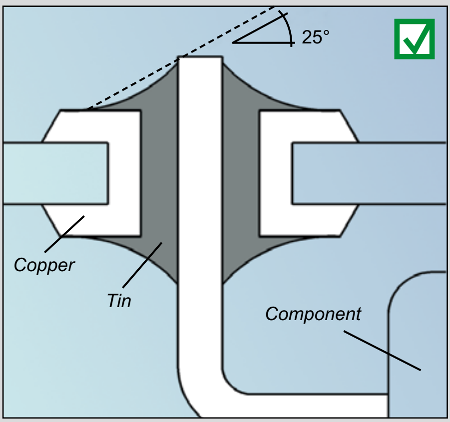
A further quality attribute is the wetting angle. This consideration is based on the fact that good wetting of the pad, discernible through a small wetting angle, has given rise to the formation of a diffusion zone (intermetallic zone). Wetting angles of up to 25º identify a good joint, wetting angles of up to 50º are still tolerable in manual soldering.

Another quality indicator is what the solder surface actually looks like. It should be smooth and shiny, without any porous areas visible. Grainy surfaces indicate either overheating of the solder or an excessive soldering time. Using lead-free solders, especially silver loaded alloys, matt surfaces may form.

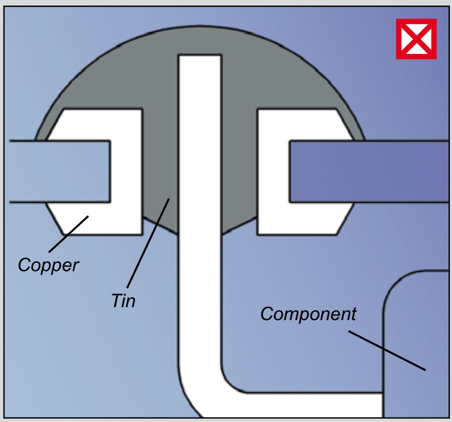
The only absolute quality indicator for a sound and strong solder joint is the formation of the diffusion zone. In the diffusion zone, intermetallic compounds of copper and tin are formed, whose presence is the final proof of quality (mixed crystals, see page 5). Unfortunately, the only way to make this zone visible is through a destructive test (sectioning of the joint). If the diffusion zone is too thick, the solder joints have no tensile strength and become brittle. The higher the soldering temperature and the longer the soldering duration, the thicker the diffusion zone will be. Therefore the joint should be made at the lowest suitable temperature and within shortest soldering times.

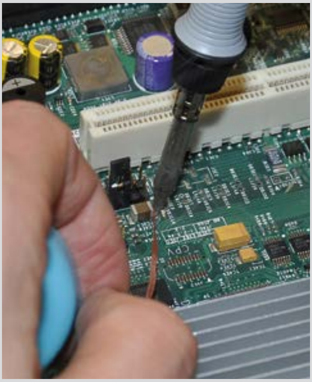
As soon as the last solder joint has been made, the soldering iron is placed securely into the holder. At this time, the tip should not be cleaned, because the remaining solder on the tip prevents oxidization.

Correct!

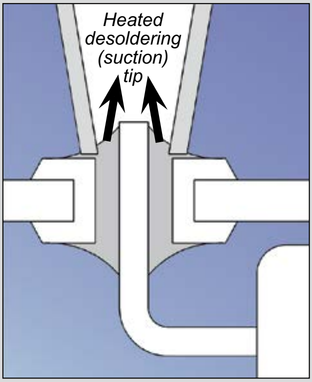


Wrong!

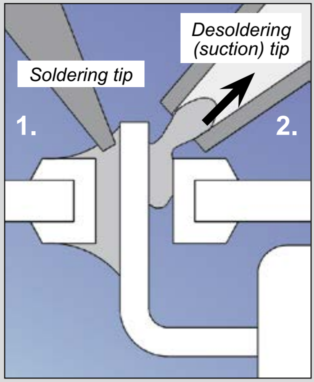




Desoldering with a solder wick



Desoldering with a temperature-controlled soldering iron



Desoldering with a desoldering pump

To achieve good results in desoldering, it is essential to select the right equipment. One can choose between desoldering wicks (desoldering using the principle of capillary action), mechanical desoldering pumps or electronically temperature-controlled desoldering systems. These are divided in desoldering systems with conductive heat or those with hot air.

Correct desoldering made easy

The right tool for each application

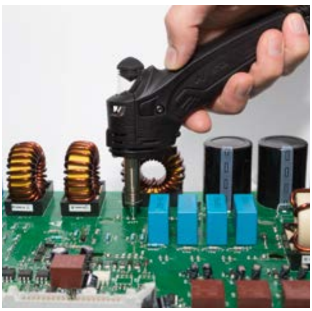
Desoldering

Reheating is not recommended for repairing a faulty solder joint. It is better to remove the solder and to resolder the joint. When using a desoldering pump, the solder joint has to be heated with the soldering iron until the solder has molten. Then the tip is removed and the desoldering pump is placed on the joint to extract the solder.

Using a heated desoldering tool, the hollow desoldering tip is placed on the joint to be repaired, making certain that there is good thermal contact. Once the solder has molten, it is extracted.

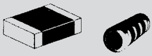
Desoldering is also dependent on proper tip selection. For example, the desoldering tip's inner diameter should be the same size as the diameter of the through-hole or even slightly larger (by max. 0.3 mm, see above drawing). The best desoldering results with least damage to PCB or the components can be achieved with temperature-controlled desoldering irons (also see pages 24/25). Please note that basically it has to be distinguished between the desoldering of through-hole components and the desoldering of SMD components.

Temperature-controlled desoldering iron

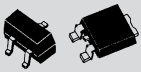


Sucking up the old, molten solder remnants with a mechanical solder sucker (desoldering pump)

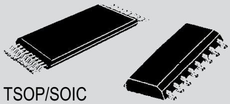
Some examples of SMD components



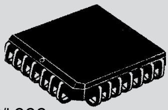
C.CAPAC./MELF



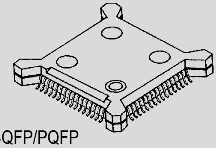
SOT&DPAK



TSOP/SOIC



PLCC/LCCC



BQFP/PQFP

Ever smaller, ever finer

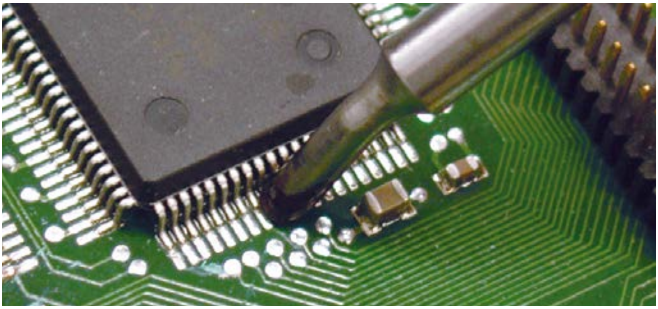
SMD technology, a true challenge

SMD Soldering

SMD technology (Surface Mount Device Technology) is currently the standard process in electronics manufacturing. Ever smaller and highly integrated surface mount components place growing demands on SMD soldering equipment.

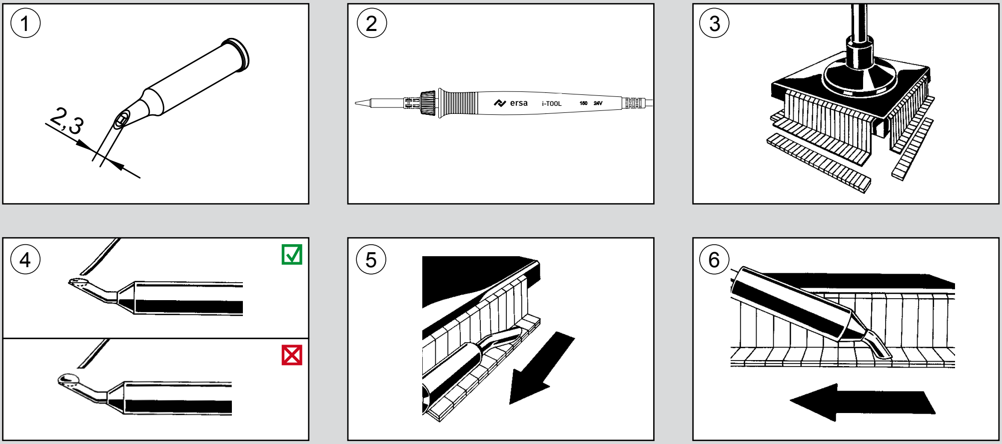
Single solder joints, for example on resistors, are made with ERSADUR long-life soldering tips starting with a diameter of 0.2 mm. Fine-pitch connections with a high pin-out, i.e. IC's, are most efficiently soldered with Ersa PowerWell soldering tips.

Ersa PowerWell technology for soldering fine pitch components within seconds



Soldering fine-pitch components

Process guide description



At first glance, soldering fine-pitch components by hand seems to be a tough job. Yet it is easy, with the right equipment at hand:

Insert an Ersa PowerWell i-TIP (1) into the i-TOOL soldering iron (2) and set a tip temperature of 285 °C to 360 °C (depending on the alloy used – tin/lead or lead-free).

Then position the component (3) and fix two corner pins.

Add flux cream (also see page 30) to the pins on all 4 sides. Clean the front and concave portion of the PowerWell tip with a damp sponge or the Ersa dry sponge.

Fill the concave portion with solder to slightly above the rim by melting the solder wire, until a small dome occurs (4). Take care not to add too much solder.

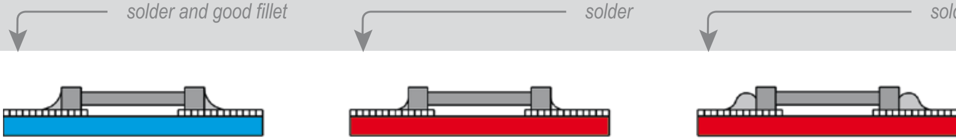
Place the i-TOOL lightly on the flat section of the pins (5), and pull the tip across the pins towards you (6) without exercising pressure.

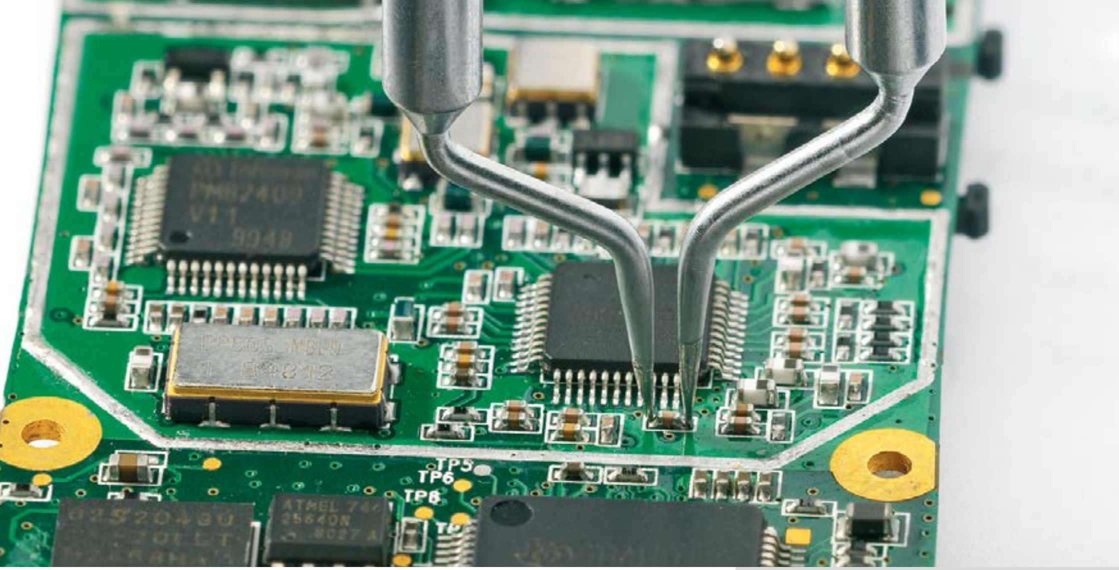
Repeat steps (4) to (6) to solder the remaining sides.

Good solder joint, sufficient solder and good fillet

Wrong: insufficient solder

Wrong: too much solder

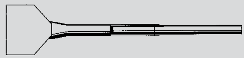




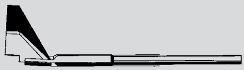
SMD desoldering in 3 seconds – with the Ersa desoldering tweezers

Some examples of different desoldering tip shapes:

to desolder and remove MELF's



to desolder and remove SOIC's



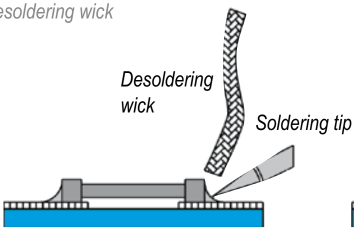
to desolder and remove QFP and PLCC components

SMD Desoldering

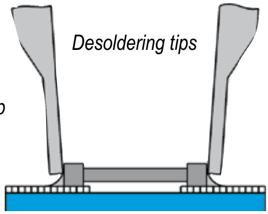
To desolder or rework a damaged SMD component, the suitable tools are required to remove the component from the board. When using desoldering tweezers, it is extremely important to select the proper pair of desoldering tips. After having desoldered the component, the pad has to be cleared of the residual solder (e. g. with a suitable soldering tip and a no-clean desoldering wick). Afterwards the new component can be positioned and soldered. An optional IR heating plate is a very useful addition – particularly in lead-free hand soldering applications.

More comprehensive instructions on SMD desoldering is available in the process description "SMD desoldering" on our website at www.ersa.com. For the soldering and desoldering of BGAs or other high pin-out SMDs, particularly those with hidden joints, we recommend the semi-automatic Ersa rework stations (see page 31).

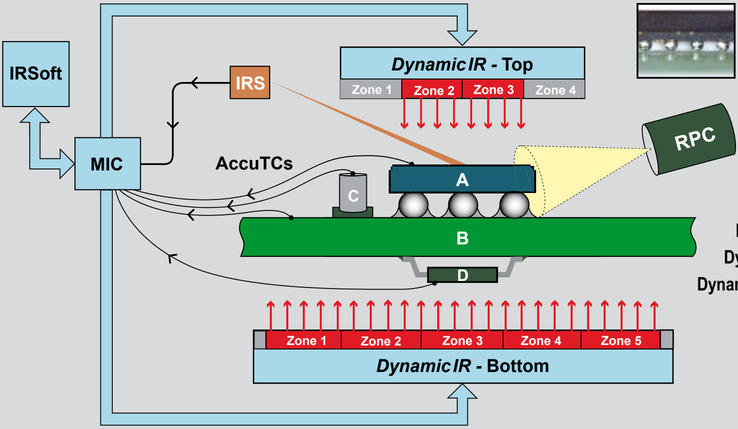
Solder melting and removal with a desoldering wick



Ersa desoldering tweezers



The compact CHIP TOOL VARIO desoldering tweezers are perfect for precise desoldering of very small SMDs.



A: Component for rework
B: PCB
C: Adjacent component (top side)
D: Adjacent component (bottom side)
AccuTCs: Thermocouples (4 each)
IntelligentIRS: Non-contact infrared sensor
DynamicIR Top: Top IR radiator (4 zones)
DynamicIR Bottom: Bottom IR radiator (5 zones)
RPC: Reflow Process Camera
IRSoft: Control & documentation software
MIC: Microprocessor controls the DynamicIR heating system

Principle of a rework station

Rework or repair soldering

The rework process demonstrated on the example of a BGA (Ball Grid Array)

Rework designates the repair or touch-up of electronic components such as Ball Grid Arrays (BGAs) or SMTs. This chapter describes the process steps for BGA rework:

1. Desoldering the BGA

The rework station heats the printed circuit board from the bottom, whereas the BGA body itself is heated from the top.

The real-time temperature of the component controls the pre-set temperature curve so that all solder joints melt at the same time. Then the vacuum suction cup is placed on the BGA and once all joints have molten the BGA is lifted off.

2. Removal of residual solder, cleaning

Solder remaining on the pads is removed with a soldering iron. To do so the residual solder is coated with flux. Then a flat soldering tip (e. g. 0102ADLF40 or 0102ZDLF150) is moved over the pad without applying any force. The solder adheres to the larger surface area of the tip, thereby levelling off the remaining solder of the connection pads. Flux residues are finally cleaned off (e. g. using Ersa FLUX-REMOVER).

3. Reballing – Reusing the BGA

Desoldered BGA's can be refit with new solder balls and re-attached to the board. This process is referred to as reballing. Residual solder is removed from the BGA by means of a soldering station. Lying on its back, the component is coated with flux first. Then the new solder balls are attached, for example by means of a stencil. These solder balls are heated up to the melting point with the rework station to firmly connect with the BGA body. Now the BGA is ready to be re-attached.

4. Application of flux or solder paste

The component and the connection pads are now fluxed, or, as the case may be, solder paste is added through stencil printing. The type of technique applied depends on the application, components and the skill level of the operators. For the commonly used PBGA's the application of flux is mostly sufficient.

5. Placing the component

Once the pad has been prepared, the component has to be placed. Since all solder joints of a BGA are hidden under the component body, a component placement unit is required. Successful visual placement by hand requires an operator with extensive experience and excellent skills. If the component is placed on solder paste deposits, great care has to be taken not to squash the solder depot, since doing so may lead to shorts after soldering.

6. Resoldering the BGA

The component is heated to the melting temperature of the solder alloy used via a controlled temperature curve. The heating continues until all solder joints have melted and remained so for some seconds. During this time durable and lasting solder joints are formed. After resoldering, the board is cooled in a similar fashion as had been done after desoldering.

These process steps are generally applicable for all surface mount components. Subject to the type of connections (wired, hidden) they may slightly vary.

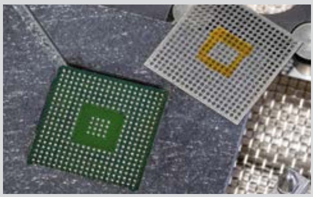
Rework – Repair of high-terminal count IC's
to successfully repair SMT assemblies, the several points must be observed:

- Dimensions and properties of the assembly have an influence on its temperature requirement
- PCB holders and supports keep the assembly flat and prevent warpage
- A gentle and controlled heating process, continuously monitored, prevents damage of components or the board
- Accurate component placement is a prerequisite for a good soldering result
- Operators that are well trained will understand the process and ensure good results

Rework process steps

1. Remove BGA

2. Remove residual solder from the pads of the board



3. Reballing – addion of new solder balls

4. Application of flux or solder paste

5. Placement of the new or reballed component

6. Resolder the BGA on the prepared surfaces of the board

Miniature soldering iron

Ersa MINOR S

MINOR S, 5 W

Ersa MINOR S (5 W), a featherweight at 6 g for ultrafine soldering applications

The **MINOR S** miniature soldering iron with a rating of 5 W and a maximum tip temperature of 440 ºC is an ideal tool for ultrafine soldering applications on micro IC's and under a microscope.
It can either operate with a 6 V transformer or a 6 V battery.

Besides electronics the MINOR S can also be used in watch repair, in the photographic industry and in dental technology.

Micro soldering irons

Ersa MULTITIP Series

MULTITIP series, 15/25 W

Ersa MULTITIP (15/25 W) internally heated soldering iron for small to medium solder joints

The **MULTITIP** soldering irons are especially short, light and easy-to-handle soldering irons with minimal distance between soldering tip and the handle's front part. They are ideally suited for small solder joints. Its internally heated soldering tip provides an enhanced degree of efficiency.

The MULTITIP is available for 15 W and 25 W which makes it suitable for micro soldering joints and medium-sized joints, as for example, on distributor strips or in the hobby sector.

Universal soldering iron

ERSA 30 S, MULTI-PRO, ERSA 15+ and ERSA 25+

Ersa universal soldering irons – for almost all applications

The proven **ERSA 30 S,** available with a 30 or 40 W rating, is a very robust and durable soldering iron. Its improved ergonomics is further enhanced by the practical stick-on rubber support disk. This universal soldering iron is designed for multi-purpose use in the crafts, service and hobby sector.

The **MULTI-PRO** with its heat-resistant power supply cord is extremely flexible, as it can be operated with a wide range of different tips. Therefore, it is suitable for almost all conventional soldering applications.

The **ERSA 15+** universal soldering iron is the ideal tool for cost-effective soldering. Internally heated soldering tips guarantee an outstanding performance. The ERSA 15+ can be operated with diverse fine tips of the 832 and 842 tip series. Its ergonomic handle assists in the safe processing of fine soldering joints.

The **ERSA 25+** is perfect for soldering applications with increased heat requirements. The internally heated, larger soldering tips of the 832 and 842 tip series ensure good heat transfer at a high thermal performance. The ergonomic handle provides a safe grip for every soldering application.

Standard and hammer soldering irons

ERSA 50 S, 80 S and 150 S / ERSA 200, 300 and 550

ERSA 50 S, 80 S, 150 S, 50/80/150 W

ERSA 200/300, 200/300 W

ERSA 550, 550 W

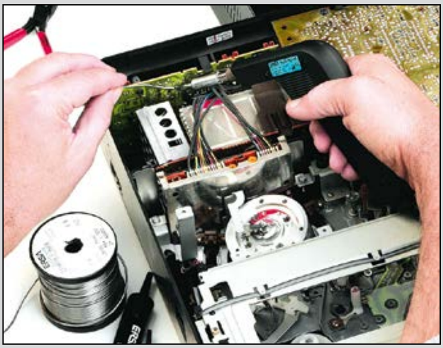
The **ERSA 50 S/80 S** or **150 S** series is designed for applications where a large amount of heating capacity is required, as, for example, on copper conductors with cross-sections of 2.5 mm to 6 mm.

The **ERSA 200, 300** and **550** hammer soldering iron series are particularly suited for sheet metal processing and installation work and for soldering commutators and copper bus bars.
Hammer soldering irons have also proven their merit in leveling applications during body work and lead glazing.

High-speed soldering iron

Ersa MULTI-SPRINT

The **Ersa MULTI-SPRINT** is an ergonomically designed and extremely light-weight, pistol-type soldering iron with up to 150 W power which does not require a transformer. Its PTC heating element, together with the internally heated ERSADUR long-life soldering tip, ensures its exceptionally high efficiency. Due to its very short heat-up time, it is ideally suited for making quick single soldering joints. The MULTI-SPRINT is powered only as long as the button is pressed. Depending on the heat requirement of the solder joint to be made, additional energy can be supplied by periodically pressing the button. The large variety of soldering tips of the 832 / 842 series make the MULTI-SPRINT suitable for more than only the use in repair and service applications.



Ersa MULTI-SPRINT, 150/75 W

Power soldering iron

Ersa MULTI-TC and PTC 70

Ersa MULTI-TC, 75 W

Ersa PTC 70, 75 W

The **MULTI-TC** and **PTC 70** are powerful and robust, temperature-controlled soldering irons. Both tools offer an outstanding heat-up rating.

Due to their high thermal performance, and because of the large selection of soldering tips, the MULTI-TC and PTC 70 are suitable for fine soldering joints in electronics as well as for joints with medium heat requirements. The MULTI-TC is furthermore also used anywhere else where standard irons with 150 W power are in use, including, for example, lead glass and Tiffany soldering.

Gas soldering irons

Ersa INDEPENDENT 75 and INDEPENDENT 130

Ersa INDEPENDENT 75, 15 – 75 W

Ersa INDEPENDENT 130, 25 – 130 W

Ersa gas soldering irons are fueled with commercially available lighter gas and are fired up through the piezo ignition. Compared with electrical soldering irons, the **INDEPENDENT 75** has between 15 – 75 W, and the **INDEPENDENT 130** between 25 – 130 W performance. Both irons are available in the BASIC-SET and PROFI-SET versions.

Aside from handling the usual types of electronic components, the selection of tips available enables the INDEPENDENT to also handle SMD soldering, micro-welding, forming and cutting of synthetic materials and the processing of shrink sleeves.

The basic soldering station

Ersa ANALOG 60

The electronically temperature-controlled ANALOG 60 is Ersa's basic soldering station model. It has the tried and proven RESISTRONIC temperature control technology with the PTC heating element serving as the temperature sensor. The high heat-up rating of 190 W guarantees the immediate supply of heat and a heat-up from room temperature to 280 ºC within 60 seconds. The BASIC TOOL 60 soldering iron uses the internally heated ERSADUR long-life soldering tips of the 832/842 series and provides very high performance.

Due to the wide range of 832/842 soldering tips, the Ersa ANALOG 60, which is also available as an antistatic version, covers a wide range of applications with the most varied soldering requirements.

Digital soldering station

Ersa RDS 80 – high performance for low cost

The digital soldering station Ersa **RDS 80** offers the proven and tested Ersa RESISTRONIC temperature control technology with a strong heating power of 80 W. The ceramic PTC heating element (Positive Temperature Coefficient) acts as the temperature sensor in this control system. Due to its very high ramp-up capability of up to 190 W, the station reaches operating temperature very fast.

RT 80: sleek soldering iron with a large selection of soldering tips

Multifunctional soldering stations

Ersa i-CON NANO and i-CON PICO – small, powerful and versatile

The soldering stations **i-CON NANO** and **i-CON PICO**, two models of the i-CON product family, fulfill all the needs of today's electronics manufacturing while requiring minimal space. They are designed for continuous operation in the electronic manufacturing environment as well as for special applications in laboratories and R&D departments.

Due to the simple and user-friendly operating concept, the factory settings provide for a variable adjustment of operating temperature as well as the setting of stand-by time and calibration value.

Further adjustments such as fixed temperatures, power level, interlock and shutdown functions are available with the free PC software and an optionally available micro smart SD card.

Micro-SD card with SD-card and USB adapter

The concept of the Ersa i-CON stations ensures that each application is processed with the optimal parameters. They stand for the highest level of process safety and quality control at low investment and operating cost.

Ersa i-CON PICO

- Small footprint (145 x 80 mm) – saves valuable space
- Antistatic as per MIL-SPEC/ESA (only i-CON NANO)
- Three fixed temperature settings or continuously adjustable temperature settings from 150 °C to 450 °C
- Three selectable power levels
- Ultra-light and ergonomic soldering tool with max. 80 W power
- Wide range of low-cost exchangeable long-life soldering tips
- Automatic stand-by and sleep function for low energy consumption and longer tip life
- Password interlock for maximum process control
- Calibration function for a precise tip temperature
- Complete parameterization through PC software and Micro-SD card

High-end soldering and desoldering stations

The Ersa i-CON product family for highest productivity and process safety

Ersa *i*-CON2 with *i*-TOOL and CHIP TOOL

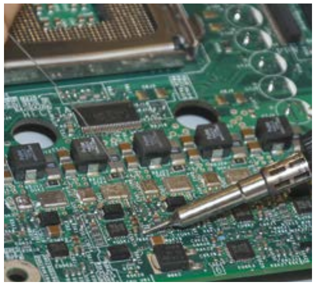
The stations of the i-CON product family are Ersa's innovative solution for intelligent manual soldering. The need to be able to cope with higher working temperatures and with progressively smaller process windows when working with lead-free solders, poses no problem whatsoever for the i-CON product family.

The i-CON is available as a single station or as double iron station. The single station **i-CON1** is delivered together with the i-TOOL soldering iron. The i-TOOL is extremely small, ultra-light and ergonomic. It is powered by a 150 W micro heating element, which realizes short heat-up times (within 9 seconds up to 350 ºC!) and rapid heat recovery.

The microprocessor which stores the temperature calibration of the iron is located in the PCB which is installed in the handle. This now allows for each individual i-TOOL to be calibrated independent of the soldering station.

In contrast to the concept followed by the cartridge-type soldering tips, only the tip itself is exchanged at the i-TOOL. The cost-intensive heating element remains.

The double iron soldering station **i-CON2** can be operated either with a second i-TOOL or with the SMD desoldering tweezers CHIP TOOL



Soldering miniature and densely placed SMD components with the i-TOOL and i-TIPS, starting at a 0.2 mm diameter.

i-CON1 with i-TOOL soldering iron with high-performance micro heating element

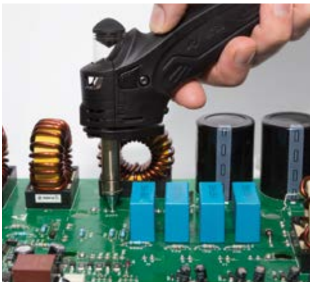
- i-TOOL soldering iron with 150 W micro heating element technology
- Low-cost exchangeable long-life tips of the i-TIP series
- User friendly "One-Touch" operation
- Three power levels – no overshoot
- Process window and alarms
- Interface to control peripheral equipment on the workplace, such as heating plate and solder fume extraction systems
- Stand-by control for tools, heating plate and solder fume extraction system
- i-TOOL calibration
- Tools for SMT and conventional soldering applications
- Automatic tool recognition

1. *Low-cost i-TIP long-life soldering tips*
2. *i-TIP tip fastener*
3. *High-power heating element (stick-on type, long-life)*

Ersa i-TOOL: The ideal soldering iron – ultra light (only 30 g), ultra short (only 155 mm), and ultra short tip-to-grip (only 45 mm) and extremely powerful.

respectively with the desoldering irons X-TOOL or X-TOOL VARIO.

The CHIP TOOL facilitates safe and quick desoldering, of the smallest chips up to large PLCC's. To remove the residual solder and to desolder wired components – also on



High-mass through-hole desoldering with the X-TOOL VARIO

User-friendly controls: quick programming & lock, huge multi-functional display with i-Op controls, menu in 7 languages, online help

multilayer boards – the X-TOOL or X-TOOL VARIO desoldering iron is the right tool.

The C-line of the i-CON stations was developed, so that peripheral equipment could be controlled or to communicate with them. Via a serial interface, the i-CON1 C or the i-CON2 C controls the Ersa IR heating plates or the Ersa solder fume extraction systems.

i-CON VARIO 4 multi-channel station with X-TOOL VARIO desoldering iron, i-TOOL soldering iron, i-TOOL AIR S hot-air iron and CHIP TOOL VARIO desoldering tweezers.

Top Tips

i-TIPS for all applications

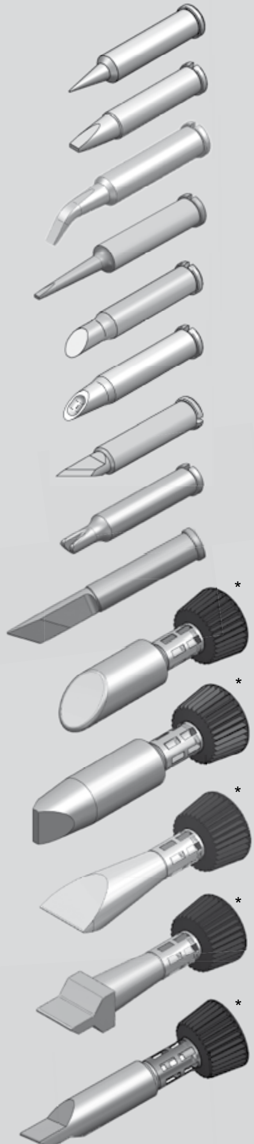
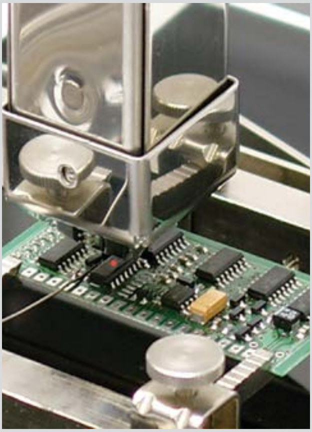


**Figure with i-TIP tip fastener*

Additional soldering tips for the i-TOOL and the i-CON soldering stations is available on our web site:
www.ersa.com

Hybrid Rework Station

Ersa HR 100 A – The innovative combination of hot air and infrared radiation



The Ersa **HR 100 A** applies the Ersa Hybrid Rework Technology for a safe desoldering and replacement of small SMD components. Its medium wave length IR radiation, combined with a safe stream of hot air ensures optimal heat transfer to the component.

The HYBRID TOOL offers a gentle and homogeneous warming of all sizes of components, from 0201 chips up to 20 x 20 mm SMD's and larger. Exchangeable hybrid adapters target the thermal energy available (up to 200 W) on to the component, all the while protecting neighboring areas and not blowing away or moving adjacent chips.

Its user-friendly handling permits even operators with little experience to safely and efficiently operate the HR 100. More experienced operators, on the other hand, can not only variably adjust the air flow as well as the heat output, but also record and run profiles. A positioning laser whose laser point makes it possible to keep track of the component worked on through the complete process is integrated in the grip of the ergonomic hybrid tool.

Complete system with HR 100 A, IR heating plate, stand for HYBRID TOOL and PCB holder.

- HYBRID TOOL with 200 W heating element, positioning laser integrated in grip
- 3 exchangeable hybrid adapters (6 x 6 mm, 10 x 10 mm and 20 x 20 mm)
- Silent rework fan (below 40 dB)
- Integrated vacuum pump and vacuum pen; tool holder and K-type thermocouple input socket; USB interface; LED display
- 2-channel temperature recording: TC & IRS; AccuTC and Flexpoint thermocouple holder
- Tool holder with z-axis height adjustment
- x-y PCB holder (290 mm x 250 mm)
- 800 W IR heating plate with glass cover: 125 mm x 125 mm IR high-performance heating element
- Rework profile and documentation software Ersa IRsoft

CLEAN-AIR solder fume extractions

Ersa EASY ARM 1 and EASY ARM 2 – protecting environment, health and resources

Ersa EASY ARM 1

Ersa EASY ARM 2

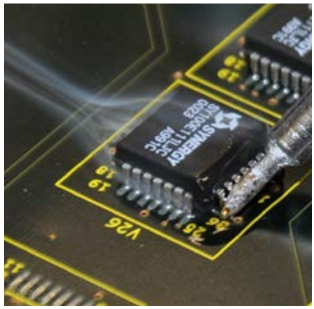
The Ersa **EASY ARM 1** is a compact yet powerful filter unit to efficiently clean the process air at the workplace. Both i-CON1 C, i-CON2 C and i-CON VARIO can be connected to the EASY ARM 1 with an interface cable. The solder fume extraction has three filtration levels to remove noxious gases.

With the solder fume extraction **EASY ARM 2**, Ersa offers the user a further compact and highly efficient fume extraction unit for either one or two workplaces. One or two units i-CON1 C / i-CON2 C / i-CON VARIO can be connected to the EASY ARM 2 via interface cable.

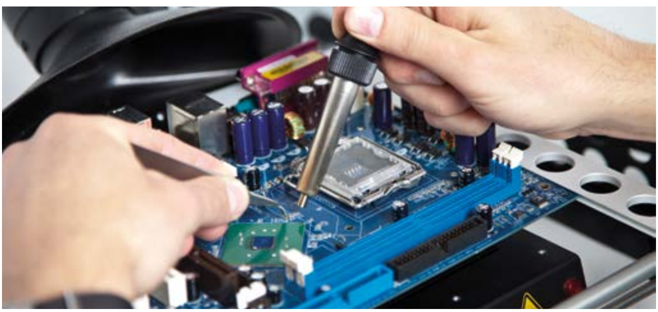
Both EASY ARM systems are provided with a stand-by mode and operate only when the soldering stations they are connected to are being used. The EASY ARM 1 and 2 are easy to install and can be placed very flexibly. Due to their very low noise level, they can be operated in virtually all environments, be it repair shops, development facilities or laboratories.

To accommodate different working conditions and applications, a variety of extraction arms and nozzle shapes which can easily and quickly be exchanged are available to meet different working conditions.

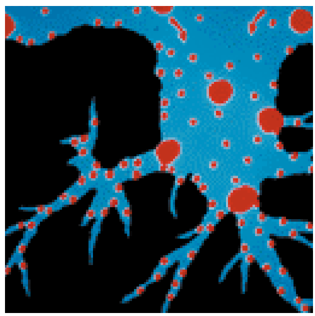
Noxious gases develop in every soldering process.



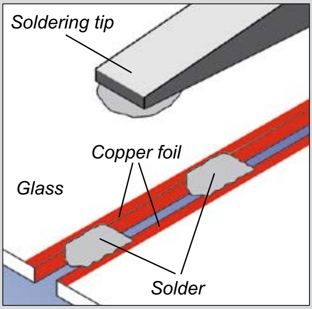
Q&A 1: So, how can you get rid of them? By using a solder fume extraction unit to clear the air from particles and gases.



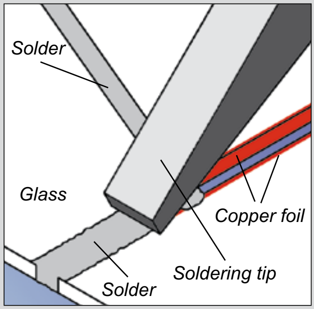
Q&A 2: How does that work? Active carbon in the filters absorbs harmful gas molecules; result: a clean working environment.



Tiffany soldering



Step 1: spot soldering



Step 2: rough soldering

Tiffany or sheet metal soldering

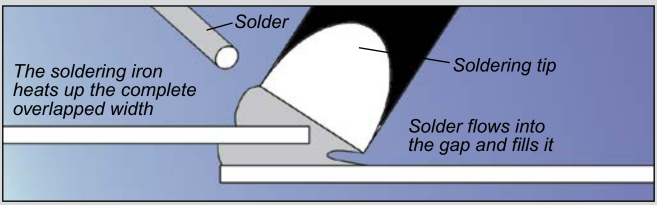
Soldering beyond the field of electronics

Tiffany soldering (Lead glass soldering)

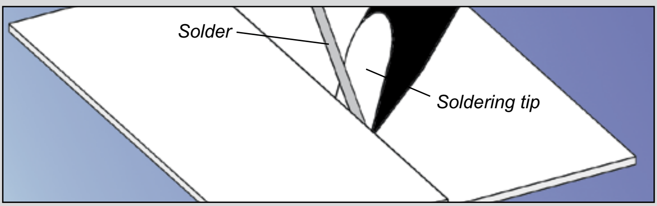
Soldering a Tiffany object generally involves three individual steps:

- Spot soldering
- Rough soldering
- Finishing

Prior to the actual soldering process, copper foil is glued on the glass edges. The next step is spot soldering, i. e. the glass parts are fastened or connected by taking a drop of solder with the tip of the soldering iron and carefully applying it to the solder joint. Each spot soldering operation should only take about a second. During rough soldering the gap between the glass is filled with solder after flux has been applied. For this purpose the tip and solder are moved together along the joint. Always drag the soldering iron, never push it. Only if this procedure is accurately followed, and if a sufficient amount of solder is applied, the desired, half-round and convex seams are achieved. The lack of visual quality of the seam at this stage is optimized during the finishing soldering step, in which the soldering tip is dragged slowly and from the beginning of the seam until the end at an even speed. The seam worked on should always lie flat on the bench.



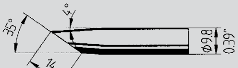
Guiding the soldering iron when soldering a broad seam



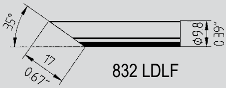
Guiding the soldering iron when soldering a narrow seam

Plumbing and tinsmith work

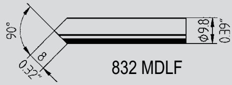
For the joining of sheet metal and metal pipes, the joints to be soldered have to be bare. This calls for a good prior cleaning.
After this, the flux – either solder grease or solder fluid, a zinc chloride solution – is applied. Then the area to be soldered is heated with the tip of the soldering iron.
Once the soldering area is sufficiently hot, solder is added and the solder gap is filled.
The aggressive flux residues are removed after cooling to avoid the risk of future corrosion.



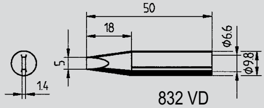
832 GDLF



832 LDLF



832 MDLF



832 VD

ERSADUR Tiffany soldering tips

The types VD, GDLF, LDLF and MDLF of the comprehensive 832 tip series are particularly suited for Tiffany work. On account of their shapes and their high mass (excellent because of the ensuing heat retention capacity), the seams between the glass parts can quickly and easily be filled with solder. And the ERSADUR finish warrants a long tip lifetime.

ERSADUR Tiffany soldering tips

Ersa DIGITAL 2000A, Ersa MULTI-TC and ERSADUR soldering tips

Tiffany lamp

The **MULTI-TC** soldering iron is very light, robust and powerful. The Ersa SENSOTRONIC Control with the PT-1000 temperature sensor in the tip reacts immediately when heat is withdrawn.

The MULTI-TC is provided with a 2.2 mm wide, chisel-shaped soldering tip. Together with the Tiffany soldering tips, the slim MULTI-TC is superbly suited for the use in Tiffany work.

Due to its precise temperature control, the **DIGITAL 2000 A** soldering station completely eliminates the possibility to overheat any glass components or the copper foil, and the station has tremendous power reserves, making it comparable and putting it on an equal level with unregulated 150 W soldering irons.

The Ersa SENSOTRONIC control with its internally heated soldering tip, where the temperature sensor is mounted directly below the tip, provides for precise temperature control and ensures uniform temperature levels at the soldering joint.

The long-life ceramic PTC heating element provides up to 290 W heat-up rating which means that the powerful soldering iron is ready for use in only 60 seconds.

The DIGITAL 2000 A is provided with a 2.2 mm wide, chisel-shaped soldering tip. Particularly good results are achieved with the optionally available tip versions 832 VD, 832 GDLF, 832 CDLF and 832 MDLF, which are specifically offered for Tiffany applications.

Ersa MULTI-TC, 75 Watt

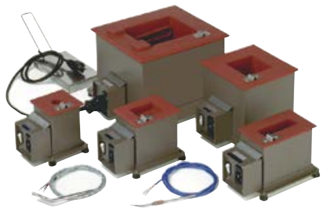
Ersa DIGITAL 2000 A with POWER TOOL

Ersa tool holders or stick-on rubber supports to safely and ergonomically put down the soldering iron during work stoppages or during heat-up.

Ersa viscose cleaning sponges for moist or special metal wool for dry cleaning of the hot soldering tip prior to the soldering process.

Auxiliary products and practical accessories

Everything for your soldering needs from one source



Ersa solder baths

Ersa solder wire and solder wire dispenser

Ersa DTM 100 temperature measuring device

Ersa desoldering wicks

Ersa tip exchanger

Ersa SOLDAPULLT desoldering pump

Ersa VAC X desoldering pump

Ersa SMD flux and flux cream

Ersa FLUX-REMOVER

Ersa TIP-REACTIVATOR

Further peripherals and accessories can be obtained from your local Ersa distributor and at **www.ersa.com**. Or just ask for our catalog!

IR rework stations

Ersa IR/PL 550, IR/PL 650 and HR 600 – from mobile phone boards up to XXL boards

Ersa HR 600

More than 5,000 customers worldwide use Ersa's patented IR-Rework technology.

Ersa rework stations deploy the DynamicIR Heating Technology, programmable top and bottom heating zones as well as the accurate, user-friendly and motorized "Auto Pick & Place" feature. System control, process documentation and visualization is handled by the Ersa rework software IRSoft/HRSoft.

Optical solder joint inspection

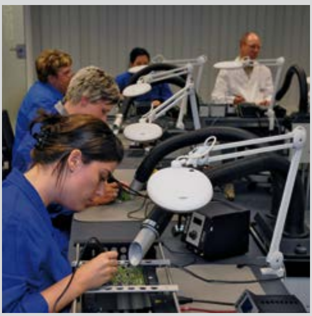
ERSASCOPE inspection systems – the patented original

Since its introduction over 10 years ago more than 3,000 customers worldwide profit from the possibility to non-destructively inspect hidden solder joints.

Regardless of whether the joints are under a flip-chip, or whether areas are to be inspected where other microscopes have come to their limits – the ERSASCOPE technology offers a considerable added value to any quality assurance program!

Ersa Know-How Seminars

Expert knowledge for professional users comprehensively imparted



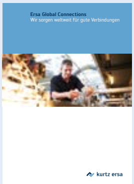
Today more than ever, cost-effective production and highest quality in the electronics manufacturing industry is the basis for profitable competitiveness. A key ingredient for being competitive is a well-qualified staff, which is up-to-date on current technology and process.

Ersa Know-How Seminars are ideal for transmitting this knowledge to those of your staff members with process responsibility in electronic manufacturing. In these seminars, theoretical and practical knowledge is presented in a neutral fashion in workshops and presentations by reputed experts in their field.

For further information go to our website **www.ersa.com** and click "Events".

Ersa Electronics Production Equipment

Technical data and further detailed information on our range of hand soldering equipment is available in our "Soldering Tools" catalog. This is available in printed form and as PDF, as are the "Rework & Inspection" catalog.



Aside from the extensive selection of hand soldering tools, rework stations and inspection systems for non-destructive inspection, Ersa, as Europe's largest manufacturer of soldering systems, also offers a complete range of selective, wave and reflow soldering systems, as well as stencil printers for the industrial electronic manufacturing industry.

Please refer to our brochures and our website **www.ersa.com** for further information.

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kurtz ersa

Soldering Guide

Safety Precautions

- **Never touch the element or tip of the soldering iron.**
  They are very hot (about 400°C) and will give you a nasty burn.
- **Take great care to avoid touching the mains flex with the tip of the iron.**
  The iron should have a heatproof flex for extra protection. Ordinary plastic flex melts immediately if touched by a hot iron and there is a risk of burns and electric shock.
- **Always return the soldering iron to its stand when not in use.**
  Never put it down on your workbench, even for a moment!
- **Allow joints a minute or so to cool down before you touch them.**
- **Work in a well-ventilated area.**
  The smoke formed as you melt solder is mostly from the flux and quite irritating. Avoid breathing it by keeping you head to the side of, not above, your work.
- **Wash your hands after using solder.**
  Solder contains lead.

Treatment for minor burns

Most burns from soldering are likely to be minor and treatment is simple:

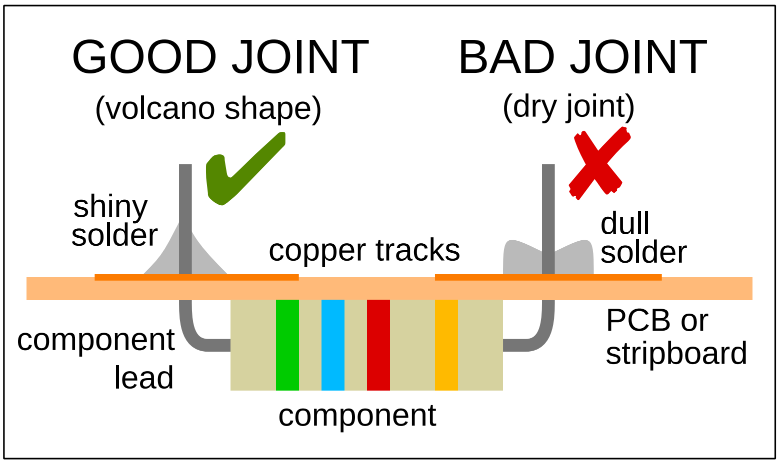
- **Immediately cool the affected area under gently running cold water.**
  Keep the burn in the cold water for at least 5 minutes (15 minutes is recommended). If ice is readily available this can be helpful too, but do not delay the initial cooling with cold water.
- **Do not apply any creams or ointments.**
  The burn will heal better without them. A dry dressing, such as a clean handkerchief, may be applied if you wish to protect the area from dirt.
- **Seek medical attention if the burn covers an area bigger than your hand.**

Preparing the soldering iron

- **Place the soldering iron in its stand and plug in.**
  The iron will take a few minutes to reach its operating temperature of about 400°C.
- **Dampen the sponge in the stand.**
  The best way to do this is to lift it out the stand and hold it under a cold tap for a moment, then squeeze to remove excess water. It should be damp, not dripping wet.
- **Wait a few minutes for the soldering iron to warm up.**
  You can check if it is ready by trying to melt a little solder on the tip.
- **Wipe the tip of the iron on the damp sponge.**
  This will clean the tip.
- **Melt a little solder on the tip of the iron.**
  This is called 'tinning' and it will help the heat to flow from the iron's tip to the joint. It only needs to be done when you plug in the iron, and occasionally while soldering if you need to wipe the tip clean on the sponge.
- **You are now ready to start soldering!**
  Please turn the page for further instructions...

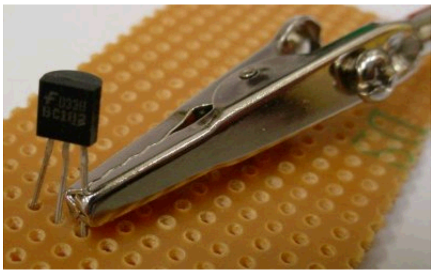
Making soldered joints

- **Hold the soldering iron like a pen, near the base of the handle.**
  Imagine you are going to write your name!
  Remember to never touch the hot element or tip.
- **Touch the soldering iron onto the joint to be made.**
  Make sure it touches both the component lead and the track.
  Hold the tip there for a few seconds and...
- **Feed a little solder onto the joint.**
  It should flow smoothly onto the lead and track to form a volcano shape as shown in the diagram below. Make sure you apply the solder to the joint, not the iron.
- **Remove the solder, then the iron, while keeping the joint still.**
  Allow the joint a few seconds to cool before you move the circuit board.
- **Inspect the joint closely.**
  It should look shiny and have a 'volcano' shape. If not, you will need to reheat it and feed in a little more solder. This time ensure that both the lead and track are heated fully before applying solder.



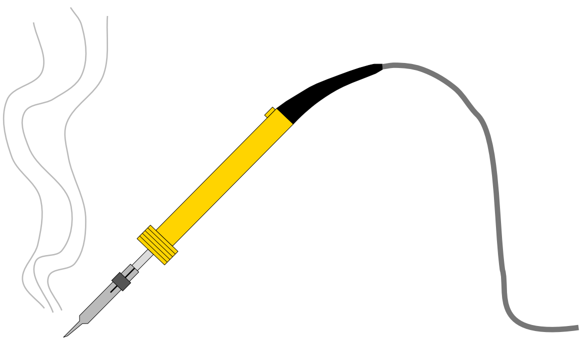
Using a heat sink

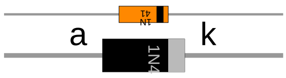
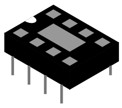
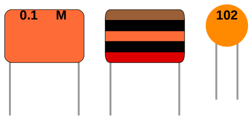
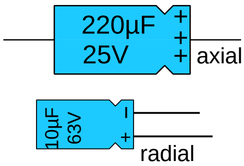
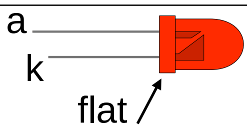
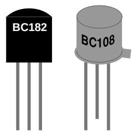
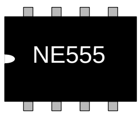
Some components, such as transistors, can be damaged by heat when soldering. It is wise to use a heat sink clipped to the lead between the joint and the component body, as shown in the picture. You can buy a special tool, but a standard crocodile clip works just as well and is cheaper!



Soldering advice for components

Some components require special care when soldering. Many must be placed the correct way round and a few are easily damaged by the heat from soldering. Appropriate warnings are given in the table on the next page, together with other advice which may be useful when soldering.



Components	Pictures	Soldering advice
Resistors		No special precautions are required. Connect either way round.
Diodes		Diodes must be connected the correct way round: a = anode, k = cathode. Use a heat sink with germanium diodes.
IC holders (DIL sockets)		Ensure the notch is at the correct end. Do **not** insert the IC at this stage to prevent it being damaged by heat.
Presets (small variable resistors)		No special precautions are required. On stripboard take care to ensure you insert them the correct way round.
Capacitors, non-polarised (less than 1µF)		No special precautions are required. Connect either way round. Take care to identify their value.
Capacitors, electrolytic (1µF and greater)		Electrolytic capacitors must be connected the correct way round, they are marked with + or - near one lead.
LEDs (Light Emitting Diodes)		LEDs must be connected the correct way round: a = anode, k = cathode. Use a heat sink with small (3mm) LEDs.
Transistors		Transistors have three leads and must be connected the correct way round. Use a heat sink clipped to each lead in turn between the joint and the transistor.
Wire links between points on the board		Use tinned copper wire (such as the offcut from a resistor lead) or single-core plastic-coated wire.
Other parts mounted on the board		No special precautions are required for most parts, but make sure they are the correct way round.
Battery clips, buzzers and other parts with wires		Red (+) and black (-) wires must be connected the correct way round.
Wires to parts off the board such as switches		Use plastic-coated stranded wire which is flexible, single-core wire is likely to break at the joint.
Integrated Circuits (ICs or 'chips')		When all soldering is complete, carefully insert ICs the correct way round in their holders. Make sure all the pins are lined up before pushing in firmly.

For further information about electronic components please see: www.kpsec.freeuk.com

Desoldering

At some stage you will probably need to desolder a joint to remove or re-position a wire or component. There are two ways to remove the solder:

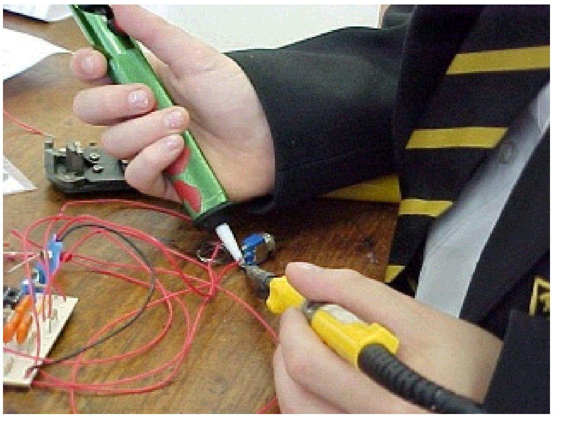
1. With a desoldering pump (solder sucker)

- Set the pump by pushing the spring-loaded plunger down until it locks.
- Apply both the pump nozzle and the tip of your soldering iron to the joint.
- Wait a second or two for the solder to melt.
- Then press the button on the pump to release the plunger and suck the molten solder into the tool.
- Repeat if necessary to remove as much solder as possible.
- The pump will need emptying occasionally by unscrewing the nozzle.

2. With solder remover wick (copper braid)

- Apply both the end of the wick and the tip of your soldering iron to the joint.
- As the solder melts most of it will flow onto the wick, away from the joint.
- Remove the wick first, then the soldering iron.
- Cut off and discard the end of the wick coated with solder.

After removing most of the solder from the joint(s) you may be able to remove the wire or component lead straight away (allow a few seconds for it to cool). If the joint will not come apart easily apply your soldering iron to melt the remaining traces of solder at the same time as pulling the joint apart, taking care to avoid burning yourself.



Using a desoldering pump (solder sucker)

What is solder?

Solder is an alloy (mixture) of tin and lead, typically 60% tin and 40% lead. It melts at a temperature of about 200°C. Coating a surface with solder is called ‘tinning’ because of the tin content of solder. Lead is poisonous and you should always wash your hands after using solder.

Solder for electronics use contains tiny cores of flux, like the wires inside a mains flex. The flux is corrosive, like an acid, and it cleans the metal surfaces as the solder melts. This is why you must melt the solder actually on the joint, not on the iron tip. Without flux most joints would fail because metals quickly oxidise and the solder itself will not flow properly onto a dirty, oxidised, metal surface.

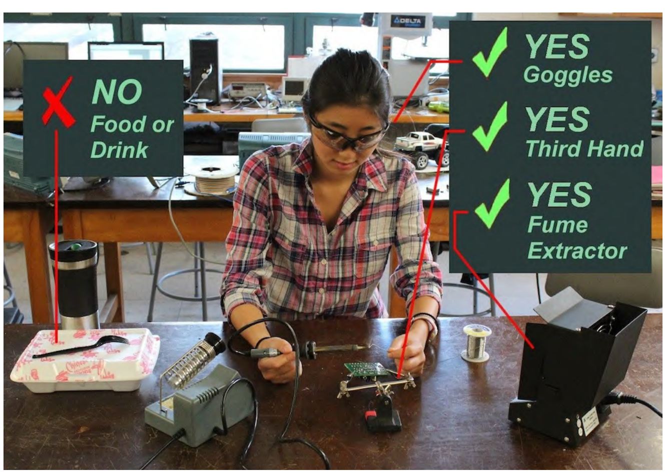
The best size of solder for electronic circuit boards is 22swg (swg = standard wire gauge).

For plugs, component holders and other larger joints you may prefer to use 18swg solder.

Safety Rules for Soldering

Department of Electrical, Computer and Biomedical Engineering, University of Rhode Island

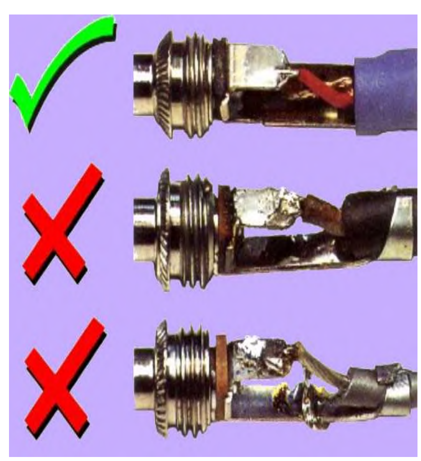
1. Wear goggles for eye protection. When trimming off leads or excess solder dross, be careful of the flyaway that could injury yourself as well as other people nearby.
2. Work in a well-ventilated area and use a fume extractor. Do not inhale fumes from the soldering processes.
3. Always return the soldering iron to its stand when not in use. Never put it down on your workbench. The soldering iron tip is very hot (about 400°C). Avoid touching plastic, wire insulator, or any flammable material in the working area with the soldering iron. Turn the soldering station to standby or off if not used for more than few minutes. Turn unit off or unplug it when done.
4. Use a third hand, a circuit board vice, pliers, tweezers, or clamps for holding components to avoid burns. Legs and arms should be covered to avoid burns from splashed hot solder.
5. Do not have food or drink near the working area. The solder is usually a tin/lead alloy and lead is toxic. The flux is a chemical used to help metal parts soldered together. It is acidic and toxic. Clean up spilled flux immediately. Wash hands after soldering. Flux can cause acid burns to the skin or damage clothing. In case of acid burns, flush immediately with water.
6. Wash hands thoroughly after handling flux and solder containing lead. Use lead-free solder whenever possible.
7. Clean up the area when finished. Discard lead and silver solder and dross in a container with a lid. Label the container: "Lead/Silver Solder Waste for Recycling". Used solder sponges and contaminated rags must be disposed of as hazardous waste.



Soldering Techniques

1. Basic tools include an electric soldering station (a temperature-adjustable type preferred), solder, a pair of needle-nose pliers, a wire stripper, a flush cutter, a desoldering bulb, a utility blade, and a third hand or a vice.
2. Workspace should be as uncluttered as possible. Clear the path between the soldering station stand and the project to be soldered.
3. Prepare the soldering iron tip. Scrape off oxides with a utility blade if necessary. Adjust to an appropriate temperature. It won't work if you can't get the solder melt onto the soldering tip. Tinning the soldering tip by coating it with a thin coat of solder. This helps heat transfer between the tip and the components. The cleaning sponge should be soaking wet. Quickly run the soldering tip over the wet sponge to get rid of excess solder.
4. Clean the contact surfaces of the metal parts if necessary. Scrape off oxides with a utility blade. In some cases, it is easier to tin the individual components first before joining them.
5. Position the components using a third hand or a vice. Avoid holding the metal part of a component with your fingers.
6. Timing is important for soldering the components together. The solder needs to be completely melt at the joint to avoid a "cold solder point." However, too much heat could damage a sensitive electronic component or melt the insulator of a wire. The required time depends on the heat transfer, which is affected by the temperature of the soldering tip, the mass of the components, the presence of flux or rosin, and how clean the contact surfaces are.
7. Start over when an attempt fails. Old solder has impurities. Remove old solder completely with a desoldering bulb or pump. Clean up flux/rosin residuals. Try again.

Examples: www.leadsdirect.co.uk/technical/perfectsolderjoint.html



Good – clean, shiny, and just the right amount of solder.

Bad – too much solder which is uneven, has sharp points in places, and was probably overheated.

Worse – uneven texture, and the flux remaining on the joint.

Soldering

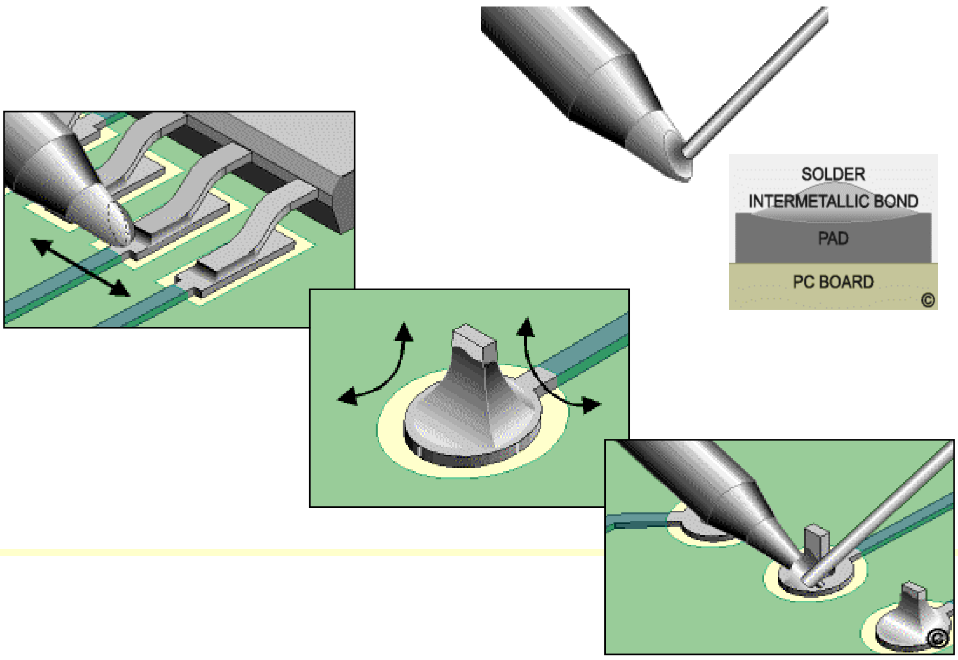


TABLE OF CONTENTS

SOLDERING

Theoretical background for technicians

1. Introduction :

Progress within the electronics industry would not have resulted in the mass production of electronic appliances as we know them today, without a similar progress in the field of soldering technology.

To be able to understand how soldering techniques are used in the electronics industry, we first have to get familiar with the materials used during the soldering process, and we have to learn how a soldering connection is created on a molecular level.

Soldering is an old technique for creating permanent electrical and mechanical connections between metals. In contrast to ordinary glueing, which makes only a physical connection between materials (although electrically conducting glue also exists) soldering causes a chemical reaction with other materials, creating a new alloy.

There are several soldering techniques, which all have a few things in common: basic metals, soldering flux, solder and heating.

2. Basic metals :

When we place electronic components on a PCB, the legs of the components and the soldering lands on the PCB, are the basic metals that will connect with the solder.
Several metals like copper, bronze, silver and some types of steel react with solder and make a strong chemical and physical connection.
Other materials like aluminium, titanium, etc. are difficult or even impossible to solder.
The fact that materials exist which can not be soldered is very important, as these materials can be used for making soldering machines and soldering irons. These materials can also be used for covering components during soldering.

There is a direct relationship between how strongly the surface of the basic metal oxidizes and how the soldering reacts on this: When there is more oxidation present, the soldering connection will be weaker.
The fact that most metals oxidize very quickly when heated, is a specific problem, because if one wants to obtain a chemical soldering reaction, a high temperature is necessary…
Flux is used to counteract this oxidation problem.

3. Soldering flux :

Although the soldering surface looks clean, there is always a thin layer of oxide on the metals. This layer always arises as soon as the metal is exposed to air. Reliable soldering connections can only be made on "clean" surfaces. "Clean" surfaces could be accomplished using cleaning product, but this would be insufficient as metal oxidizes incredibly fast when heated. To prevent the creation of the layer of oxide, the use of soldering flux is necessary.

Using soldering flux on the basic metals before the soldering starts has various reasons and advantages:

The main reason of the use of flux is to stop the oxidation of the basic metals during heating. The flux makes sure that the air can't reach the soldering surface, and therefore prevents the formation of oxidation during warming up.
Most of the different flux types have acid components which are used to remove the oxidation that is already present on the basic metal.
If a very strong acid is active in the flux, theoretically it would be possible to remove all the oxides. This however is in practice not possible, as the acid would also affect the PCB and the components, which of course is not the intention.

Therefore there will always be a search for the balance between a flux that contains strong acids, and as a consequence also removes the oxidates more effectively (but also affects the PCB), and a flux that contains a less strong acid and therefore removes less oxides. (but does not affect the PCB).

Most fluxes though use types of acid. Therefore it generally is necessary to remove the flux residues after soldering.

When solder is applied, the flux needs to flow off so that the solder can make direct contact with the basic metal. During this process it is however impossible to avoid the flux mixing with the solder.
Flux developers make use of this fact to develop a flux that has the property to reduce the surface tension of the solder on contact, as a result of which better "wetting" arises.

Flux consists of natural or synthetic resin and chemical additives, called activators.
In PEM a "no clean" flux of Tamura is used (for the placement of Flat-Package-IC's). Consequently it is not necessary to remove the flux after soldering.
Furthermore it is not necessary to add extra flux when doing easy manual soldering because the soldering wire contains flux (3.3 %), like a resin core.

4. Solder :

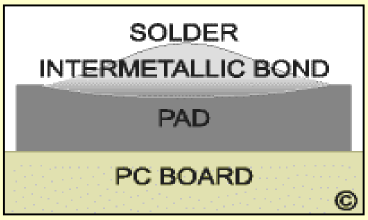
There several existing metals and metal alloys that can be used for soldering.
The choice for using a certain metal is based on the properties of the metal:
Is the metal flexible or fragile? How well does it conduct heat?
Does it expand rapidly when heated? What is the electrical resistance of the metal?
How strong is it? Is it toxic? And not unimportant: what does it cost?
Although it is not perfect, an alloy of tin and lead is most often used traditionally.
Pure tin melts at 203°C and pure lead melts at 330°C. A mixture of both metals has a lower melting point.
By using a different mixture the melting temperature of the soldering alloy can be changed.
A alloy of tin and lead (e.g. 60/40) has a relatively low melting point (183°C) and can be produced at a relatively low price, in comparison to other alloys with similar properties.
Lead is a very cheap and can be found in a lot of places. Therefore the cost of the tin-lead alloy is mainly determined by the cost of tin.

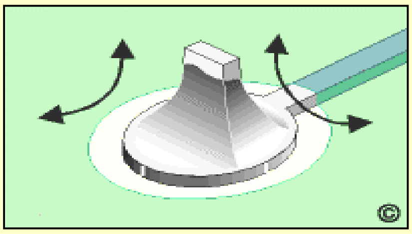
When this alloy is warmed up, it goes through several phases:
the alloy goes from a "fixed" condition, to a "paste" condition (semi-liquid), and finally becomes totally liquid. It is difficult to solder with an alloy that is in a "paste" condition: because there is little movement or vibration during this "paste" condition, this can cause bad soldering.
If the alloy is of 50% tin and 50 % lead, it starts to melt at a temperature of 193°C, and will be totally melted at a temperature of 216°C.

To prevent bad soldering during the "paste" condition, "eutectical" solder is used.
An "eutectical" alloy is an alloy that, when heated, goes immediately from a fixed condition to a liquid condition: the "paste" stage is effectively skipped.
An "eutectical" tin-lead alloy contains 63% tin and 37% lead.
Often a tin-lead alloy with 60% tin and 40% lead is used. This alloy can be produced cheaper than the eutectical solder because it contains less tin. But because this alloy is almost "eutectical", it can effectively be used for soldering.
During soldering, be careful to make no sudden movements whilst the solder is cooling.
This can cause "interrupted connections" and therefore unreliable soldering.
An "interrupted" soldering connection has a rough and irregular surface and appears dim instead of clear and shiny.
It is also very important that no impurities get into the solder.
If small metal particles from the components get into the soldering "cup" of the soldering machine.
This can result in a serious change to surface tension, and consequently bad soldering connections.
These metal impurities could even change the melting temperature of the solder.

5. Heat, generation of soldering connection

If the solder gets in contact with a copper surface,
the solder dissolves and penetrates the copper layer.
The molecules of the solder and the copper get mixed and a new
alloy is created, consisting partially of copper and partially of solder.
This reaction is called "wetting" and has as a result an "inter-metallic" connection
between the components. "Wetting" can only take place if the surface of the copper does not contain oxides. The solder and the surface of the copper also have to be at the right temperature before the "wetting" can take place.





6. Soldering with a soldering iron:

The following 4 factors determine the quality of the soldering connection:

- clean surfaces
- temperature
- time
- quantity of solder

a) Clean surfaces:

"dirt is the enemy of a good soldering connection!"

It is enormously important that there are no impurities on all of the components (including the soldering bit). Soldering on "dirty" components is not possible!
Old PCB's or components sometimes can not be soldered due to a large layer of oxide on the islands and the legs of the components.
In such cases the solder is rejected and goes to everywhere, except for where we want it to go.
In a desperate attempt to solder in such a situation, a common reaction is to raise the soldering temperature. However, this is certainly not a solution. On the contrary!
The only correct solution is thorough cleaning. (e.g. with a brush of glass fibre)

Before the soldering iron can be used, the soldering bit first has to be coated with tin.
Some solder has to be melted onto the bit. Afterwards the bit has to be cleaned.
For cleaning the soldering bit, it is best is to use a slightly moistened sponge (with demineralized water). The use of ordinary tap water is not reccomended, because the silver layer on the bit gets affected by calcium in the tap water, which results in less thermal contact. This diminished thermal contact runs the risk of cold soldering, etc.
To improve the thermal contact between the bit and the soldering surface, it is advisable to coat the soldering bit with a little bit of solder before every soldering action.

b) Temperature & time :

The temperature of the soldering bit is not the most determining factor for successful soldering: the heating cycle (combination of temperature of the bit and the time the heating takes) is!
How fast the soldering components warm up, how warm they get and how long they stay warm, are the most important factors that have to be controlled to make a reliable soldering connection.

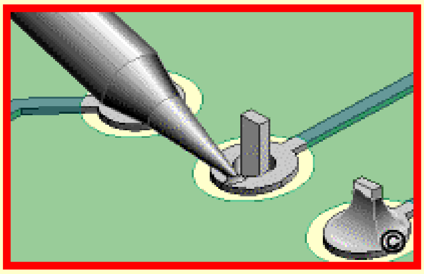
The time soldering takes is very important. A soldering task may only take a couple of seconds: when heated too long, the components and the soldering lands can be damaged.

It is also totally wrong to use the soldering bit to rub melted solder across the soldering surface.

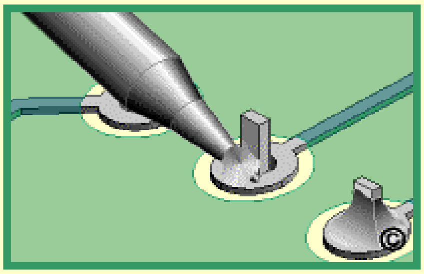
Although the temperature of the bit is not the most determining factor, it is advisable to to do soldering at the lowest possible temperature.

The first that has to be examined before the soldering starts in the 'thermal mass" of the components.

Every soldering task has its own specific "thermal mass" which is determined by the heat absorption of the components. For soldering e.g. the component pins and solder lands.
For components on a heat sink there will be a large thermal mass. In other words: the heat will be "absorbed " by the heat sink, as a result of which more warmth will have to be added than e.g. for soldering the leg of an IC.
Secondly it is very important that the temperature of all the components that will be soldered have more or less the same temperature.
An example: it is necessary that the leg and the soldering land have had at the same time the necessary warming up before the solder is added.
We have to take care that, while warming up, the soldering bit gets in contact with both the leg and the soldering land.
"Thermal contact" is therefore very important.



The thermal contact is low
The warmth is transmitted by means of the bit. to the leg and the soldering land



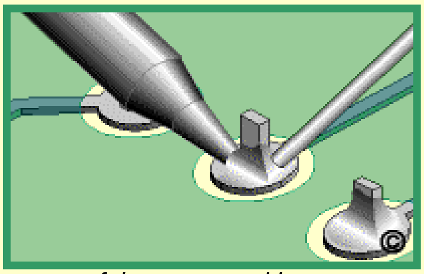
The thermal contact is higher
by adding a bit of solder to the point of contact

The size and the shape of the soldering bit, as well as the position of the bit, will determine whether or not it makes a good thermal contact. For being able to make a good thermal contact in all circumstances, different types of soldering bits exist (different shapes).
Normally the soldering bit has to be placed on the "largest mass point" of the soldering connection that needs to be made.
This will make fast heating possible.

c) Adding solder & quantity

The last factor necessary for a high quality soldering connection, is adding the correct quantity of solder.
Too much solder is an unnecessary waste and can aid the formation of "bridges" across legs
If not enough solder is added, this can cause an "insufficient soldering" or "dry soldering"
Adding the correct quantity of solder takes a lot of exercise and experience

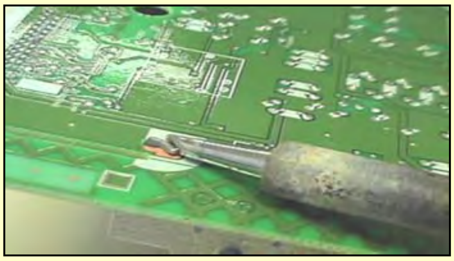
Melted solder always flows from a "colder" area to a "warmer" area.
Before the solder is added, the surface temperature of the components to be soldered has to be higher than the melting temperature of the solder.
Never let the soldering wire melt by holding it against the soldering bit. This may cause the solder to fall on a surface where the temperature is lower than the melting temperature
This can result in a cold soldering, with almost no or insufficient "wetting".
If the solder is added to a clean, fluxed and sufficiently heated surface, then the solder will melt and flow nicely without direct contact with the heat source. (soldering bit)
Therefore it is advisable to put the soldering wire on the sufficiently heated surface so that the solder melts as a consequence of the contact with the heated surface



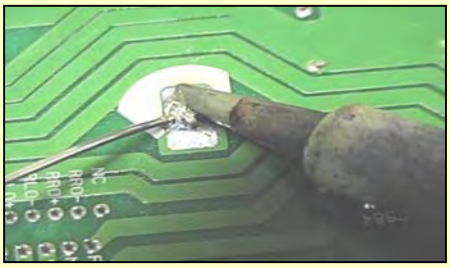
The solder is melted as a consequence of the contact with the heated surface. No contact with the soldering bit is necessary.

d) Soldering : 7 steps

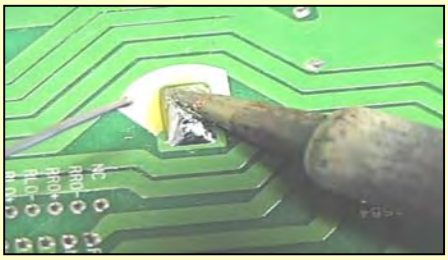
1. Cleaning of the soldering bit:
For soldering to be effective, the soldering bit has to be clean: no dirt and no oxides are allowed on the soldering bit.
The soldering bit needs to be cleaned before soldering.



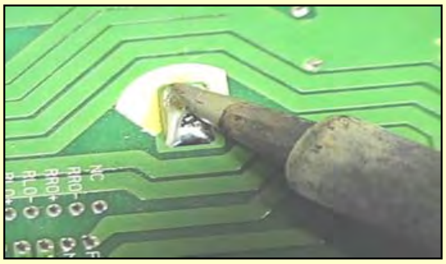
2. Heating of the components that will be soldered.
For soldering to be effective, the components which have to be connected, have to be heated (in this case the pin and the solder lands) to a temperature that at least equals the temperature of the melting point of the soldering alloy. (183 °C)
Bear in mind the "thermal mass", the type of bit and the position of the bit!



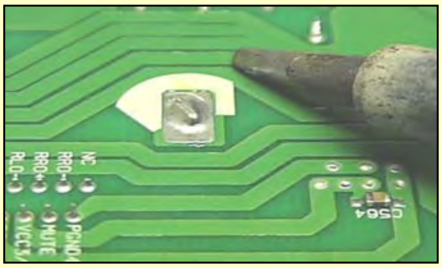
3. Adding the solder:
After both components are heated sufficiently, solder can be added.
Let the solder melt as a consequence of the contact with the heated surface. In other words: don't make any direct contact with the soldering bit.



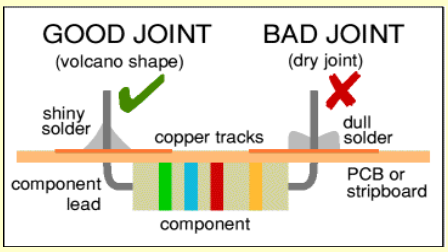
4. Quantity of the solder to be added and letting the solder flow.
Let the solder flow nicely between both components and add solder until the right quantity is reached.



5. Remove the soldering wire
When sufficient solder is added, the soldering wire may be removed.



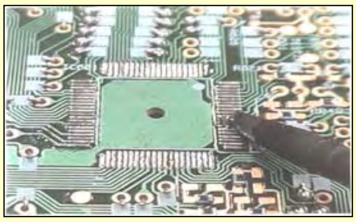
6. Remove the soldering bit.
When the solder has nicely flowed open, and there is "wetting", the soldering bit may be removed so that the solder can solidify.
Pay attention for possible sudden movements during this operation. (risk of "disturbed" soldering)



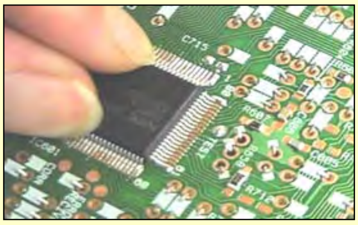
7. Check the soldering connection
Check the soldering connection.
Nicely formed soldering is shining and even. Also pay attention to the shape: a spherical shape is not good!

e) Soldering of a flatpackage IC

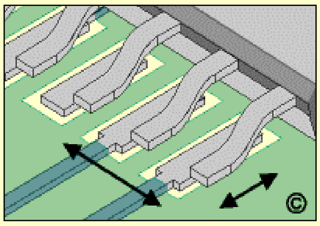
For soldering a "Flat-package IC" (gull wing type) one can use, beside the ordinary point soldering (= leg by leg), a special soldering technique: the DRAGGING TECHNIQUE.
For this technique, one must use a special soldering bit that will, after filling-up, act as a kind of "mini-soldering-wave", and with which one can solder a whole row of legs in one ongoing movement



1. Cleaning of the soldering surface:
Remove all possible soldering residues (caused by desoldering) and make all the paths nicely even by going over those paths with the soldering bit. (without adding solder)

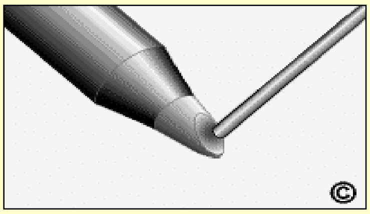


2. Positioning of the IC:
Position the IC on the patterns.
This has to be very precise.
A little movement can cause serious problems.



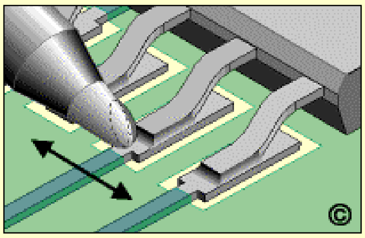
3. Fixing of the IC:
Fix the IC on the PCB, by "temporarily" soldering some legs on both sides.

4. Add sufficient flux on all sides.



5. Filling of the bit and start of the soldering:
Fill the special (concave) soldering bit with solder.

Now start a slow dragging movement from one leg to another.
Pay attention that the solder nicely moves up on the legs of the IC.

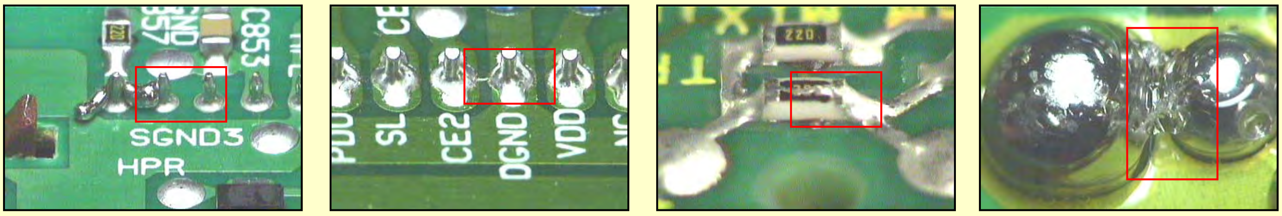


If the PCB is equipped with a "soldering thief" (a soldering land that is positioned next to the last leg), one has to solder in the direction of the soldering thief, so that at the end the possible surplus of solder flows on this soldering thief and no short circuit is created on the last two legs of the row.

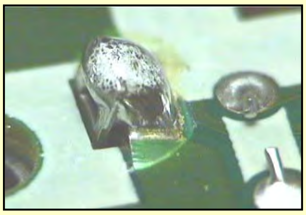
f) Incorrect soldering :

For certain soldering problems or soldering mistakes, specific terms are used:

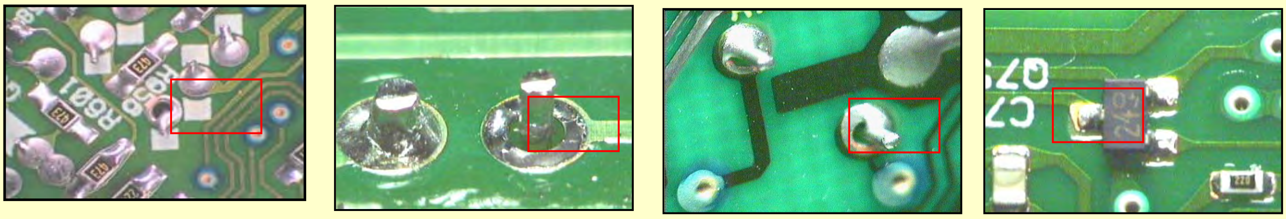
SOLDER BRIDGE



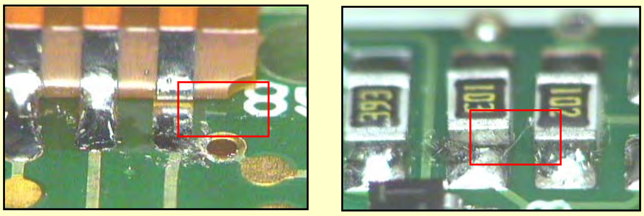
COLD SOLDERING



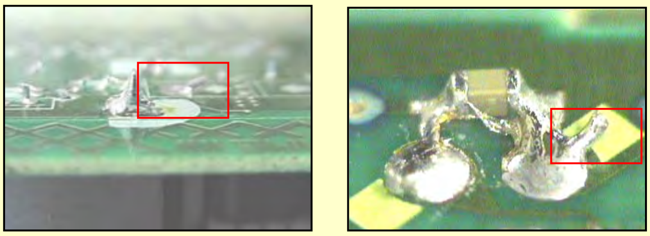
HALF SOLDERING OR DRY SOLDERING



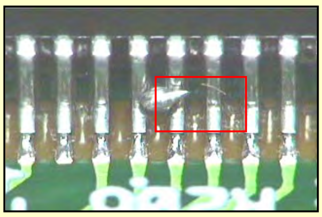
NO SOLDERING



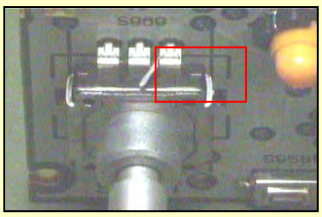
SOLDERING HORN



SOLDERING BALL OR SOLDERING SPLASH



SOLDERING WIRE SHORT CIRCUIT

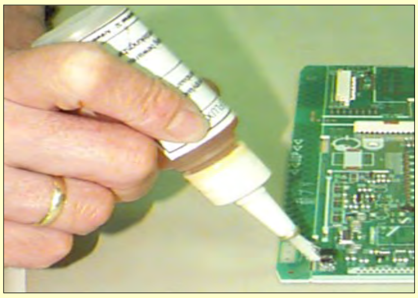


7) (De)soldering with warm air and soldering paste:

In some cases it is impossible to solder or desolder certain components with a classical soldering iron or a normal desoldering station.

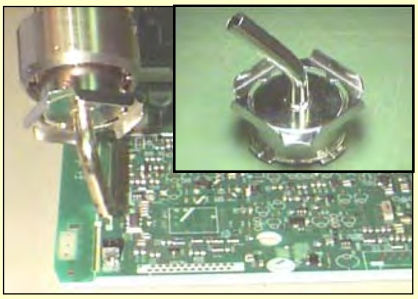
This is often the case for SMT components, with contact legs (partly) underneath the component.
In such a case one has to use a (de)soldering appliance that uses warm air or infra-red heat.

SMT component with contact surfaces beneath the component



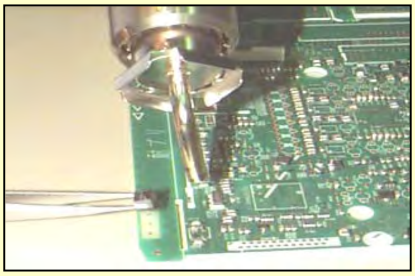
1. Fluxing of the component:

To have a good temperature conductance during warming up, the soldering surfaces need to be moistened with flux.
If these surfaces are parly underneath the component, flux can be put on the borders of the component.



2. Warming-up of the soldered surfaces:

Use a "pointing nozzle" and point it at the component you want to remove. Keep a distance of 1 cm between the nozzle and the surface you want to warm up. Choose the temperature of the warm air e.g. +/- 340°C. (dependant on the temperature profile of the compents.)
Pay attention : if the contact surfaces are partly under the component, it is necessary to warm up the body of the component. Often the component is not useable afterwards.

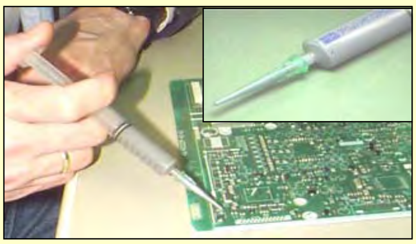


3. Removal of the component

When the solder (paste) has melted, the component can be removed with a pair of tweezers.

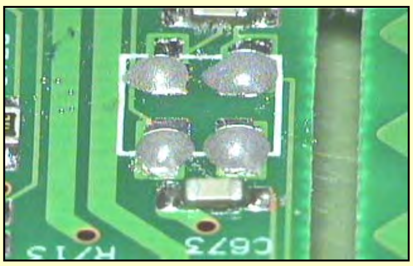
4. Cleaning of the soldering surfaces:

Remove all redundant soldering paste with a classical desoldering station.



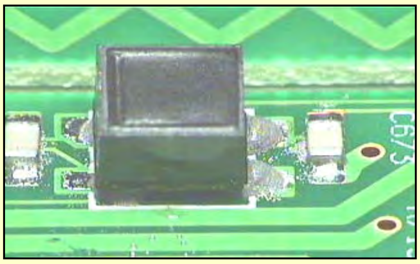
5. Adding soldering paste:

Add with a measured squirt the necessary soldering paste on the soldering lands.
Pay attention: soldering paste needs to be stored in strict circumstances. (see the instructions of the supplier)



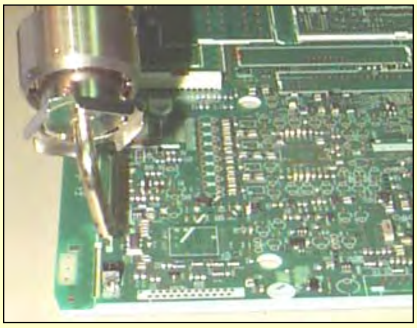
6. Checking the quantity of soldering paste:

Check the quantity of the added soldering paste.
Only the contact surfaces should be covered with soldering paste.
Too much soldering paste can cause a short circuit during "re-flowing".



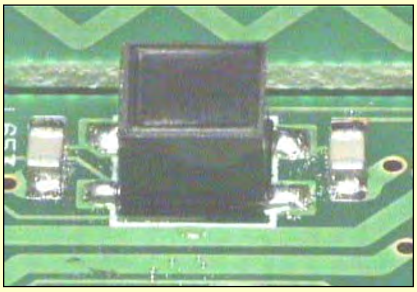
7. Positioning of the component

Position the new component carefully with the contact surfaces in the soldering paste with a pair of tweezers.
Position the component by the guide lines on the PCB.



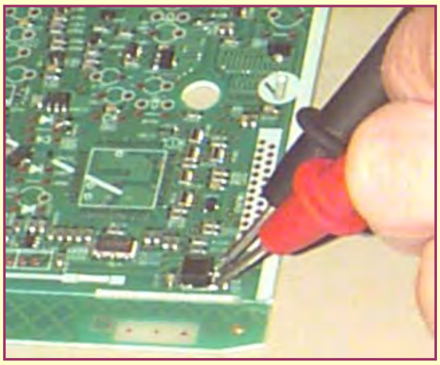
8. Reflowing of the component:

Use a "pointing nozzle" and point it on the component you want to remove. Keep a distance of 1 cm between the nozzle and the surface you want to warm up. Choose the temperature of the warm air e.g. +/- 340°C. (dependant on the temperature profile of the component.) Warm up until one sees that the soldering paste is active or flowing. The result should be a good soldered joint.
Pay attention: For most of the warm air soldering appliances one can choose the air pressure. The speed should be minimum, otherwise there is a possibility of blowing the component away.



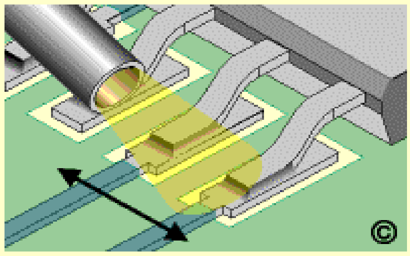
9. Checking of the soldering:

If possible, check the soldered joints.
Good soldering shines and has flowed evenly.



10. Checking of the electrical connection

If possible check the electrical connection with a meter.



Example of a "warm air soldering appliance": PACE.

8) Lead free soldering

Introduction.

Normally all solderings (mechanical - and hand soldering) were executed with soldering material that contained lead. (40 % lead / 60 % tin)

But lead is toxic and therefore damaging for humans and for nature.

Hence European directives were made in which companies will be obliged to use soldering techniques without lead after July 2006.

Soldering without lead is relatively new in the world of electronics.

Lead-free solder:

If no lead is present in the soldering wire, this has to be replaced. The soldering wire needs to contain another metal, like SILVER & COPPER. (96,5 % tin / 3% silver / 0,5 % copper)

This new composition has the advantage that it is no longer toxic and that the soldering connections are stronger. (lead is relatively weak). But this new composition also has some negative consequences:

1) The cost is higher (silver and copper alloys are more expensive than lead)
2) The joints look different (more granular instead of shining)
3) The melting temperature is higher

One of the main points of interest is the higher melting temperature. One would think that as a consequence of the higher melting temperature of the solder, also the soldering temperature needs to be raised. This however is not always allowed! Some components are only able to handle a certain maximum temperature for a certain time.

In practice.

- You can use your original soldering station if you can reach the correct temperature at the soldertip
- The soldering bit has to be a bit larger than a soldering bit for soldering with lead.

Pay attention: **Solder with lead and solder without lead can never be mixed.**

9) Temperature specifications of the soldering bit

Solder with lead

Process	**Bit Type**	**Solder**	**Min**	**Center**	**Max**
Pins	ETB / ETCC/ 1121-0519	UOS-014	340°C	**380°C**	400°C
LCD	ETF / ETCC	UOS-005	320°C	**340°C**	360°C
OEL Display	ETCC	UOS-004	280°C	**290°C**	300°C
Connector	ETL / ETF	UOS-005	320°C	**340°C**	360°C
Flexible PCB	ETF	UOS-004	280°C	**300°C**	320°C
IC's & QFP IC's	1121-0490	UOS-005	280°C	**300°C**	320°C
Removal bridge	ETB / ETCC	UOS-005	320°C	**340°C**	360°C
Lights	ETF / ETB /1121-0519	UOS-005	280°C	**300°C**	320°C
SMT/SMD repair	ETL / ETF	UOS-005	280°C	**300°C**	320°C

Temp. specifications Pioneer standard ZES-A015 & ZES-B016

Solder without lead

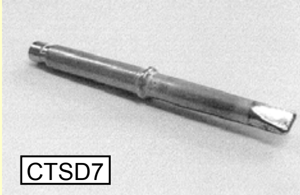
Process	**Bit Type**	**Solder**	**Min**	**Center**	**Max**
Pins	LTB / LTCC	UOS-026	400°C	**410°C**	420°C
LCD	LTF / LTCC	UOS-027	320°C	**340°C**	360°C
OEL Display	LTCC	UOS-028	280°C	**300°C**	320°C
Connector	LTL / LTF	UOS-027	320°C	**340°C**	360°C
Flexible PCB	LTF	UOS-028	280°C	**300°C**	320°C
IC's & QFP IC's	1121-0490	UOS-027	280°C	**300°C**	320°C
Removal bridge	LTB / LTCC	UOS-027	320°C	**340°C**	360°C
Lights	LTF / LTB	UOS-027	280°C	**300°C**	320°C
SMT/SMD repair	LTL / LTF	UOS-027	280°C	**300°C**	320°C

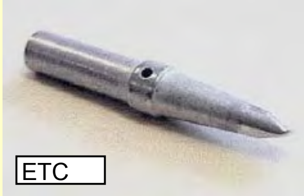
Temp. specifications Pioneer standard ZES-A043

Types of soldering wire:

With lead	UOS-014 (1 mm) + UOS-005 (0.8 mm) + UOS-004 (0.5mm)
Without lead	UOS-026 (1 mm) + UOS-027 (0.8 mm) + UOS-028 (0.5 mm)

10) Types of soldering bits:



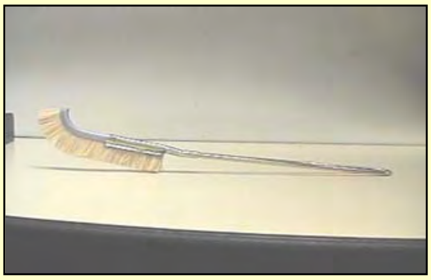


11) Soldering devices:

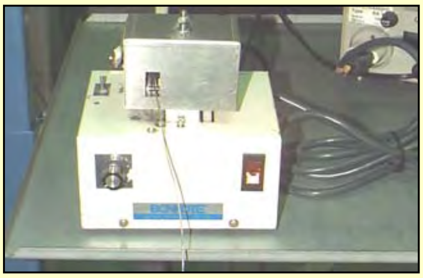
"Clean-o-point": for automatic cleaning of the soldering bit with 2 rotating sponges

"Flux dosing bottle": for easy adding of flux (with brush)

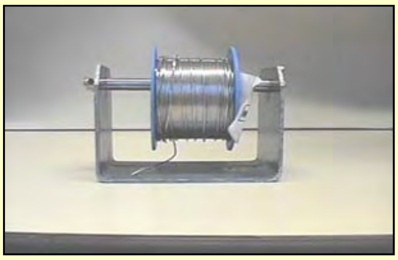
"Bit cleaner": for drying and cleaning of the soldering bit



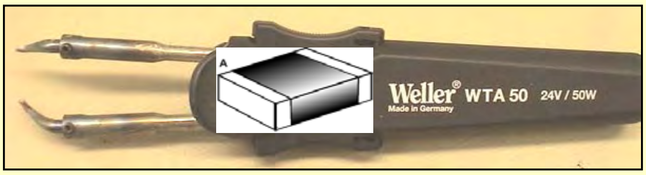
" Brush" : for removal of possible soldering residues after soldering



"V-cutter" : for making a cut in the soldering wire, in order to reduce the formation of little soldering balls

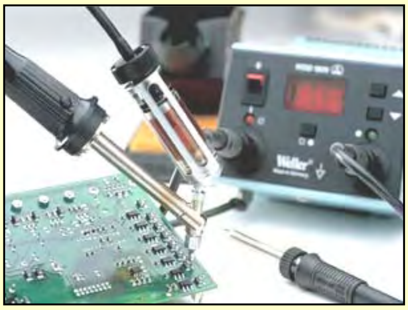


"Solder dispenser" : for a simple supply of soldering wire



"Tweezer-copper bit": handy tool for the removal of SMD/SMT components.

"Warm air desoldering appliance": for easy desoldering of flat-package IC's



"Desoldering appliance": for easy desoldering of point solderings

"Soldering magnifying glass": for a good view during soldering

The Basic Soldering Guide

http://www.epemag.wimborne.co.uk/solderfaq.htm (for text in this document)

basics for wire (Good intro) : http://www.youtube.com/watch?v=BLfXXRfRIzY
The Happy Soldering Iron: http://www.youtube.com/watch?v=AL-_RGbyf1s
basics: http://www.youtube.com/watch?v=I_NU2ruzyc4
Watt/temp comparison http://www.youtube.com/watch?v=Vh9pWu6K6tc&NR=1
tip sizes: http://www.youtube.com/watch?v=Sfb1Ve52ztY&NR=1
types of solder: http://www.youtube.com/watch?v=COqGkYMOA44
maintenance: http://www.youtube.com/watch?v=krxTfZCFptk&NR=1

Good overview with some odd bits: http://www.youtube.com/watch?v=AOdnGUMi7lQ

Desoldering overview: http://www.youtube.com/watch?v=j-_pnc-Qqm8
2nd good overview: http://www.youtube.com/watch?v=8UN3D2-f64A
Hot air pencil/gun: http://www.youtube.com/watch?v=AxYhF6Ab2CU
Desoldering gun (short): http://www.youtube.com/watch?v=8Z6MvZz_uNc

Crazy Guy from Make Electronics: http://www.youtube.com/watch?v=3N3ApzmyjzE
Not Soldering!! – Bread board: http://www.youtube.com/watch?v=oiqNaSPTI7w

This written guide will help beginners and novices to obtain effective results when soldering **electronic components**. If you have little or no experience of using a soldering iron, then EPE *(Everyday Practical Electronics* magazine) recommends that you practice your soldering technique on some fresh surplus components and clean stripboard (protoboard), before experimenting with a proper constructional project. This will help you to avoid the risk of disappointment when you start to assemble your first prototypes. If you've never soldered before, then read on!

Soldering irons

The most fundamental skill needed to assemble any electronic project is that of ***soldering***. It takes some practice to make the perfect joint, but, like riding a bicycle, once learned is never forgotten! The idea is simple: to join electrical parts together to form an electrical connection, using a molten mixture of lead and tin (solder*) with a soldering iron. A large range of soldering irons is available - which one is suitable for you depends on your budget and how serious your interest in electronics is.

[*Note: the use of lead in solder is now increasingly prohibited in many countries. "Lead free" solder is now statutory instead.]

Electronics catalogues often include a selection of well-known brands of soldering iron. Excellent British-made ones include the universally popular Antex, Adcola and Litesold makes. Other popular brands include those made by Weller and Ungar. A very basic mains electric soldering iron can cost from under £5 (US$ 8), but expect a reasonable model to be approximately £10-£12 (US$ 16 - 20) - though it's possible to spend into three figures on a soldering iron "station" if you're really serious! Check some suppliers' catalogues for some typical types. Certain factors you need to bear in mind include:-

Voltage: most irons run from the mains at 240V. However, low voltage types (e.g. 12V or 24V) generally form part of a "soldering station" and are designed to be used with a special controller made by the same manufacturer.

Wattage: Typically, they may have a power rating of between 15-25 watts or so, which is fine for most work. A higher wattage does ***not*** mean that the iron runs hotter - it simply means that there is more power in reserve for coping with larger joints. This also depends partly on the design of the "bit" (the tip of the iron). Consider a higher wattage iron simply as being more "unstoppable" when it comes to heavier-duty work, because it won't cool down so quickly.

Temperature Control: the simplest and cheapest types don't have any form of temperature regulation. Simply plug them in and switch them on! Thermal regulation is "designed in" (by physics, not electronics!): they may be described as "thermally balanced" so that they have some degree of temperature "matching" but their output will otherwise not be controlled. Unregulated irons form an ideal general purpose iron for most users, and they generally cope well with printed circuit board soldering and general interwiring. Most of these "miniature" types of iron will be of little use when attempting to solder large joints (e.g. very large terminals or very thick wires) because the component being soldered will "sink" heat away from the tip of the iron, cooling it down too much. (This is where a higher wattage comes in useful.)

A proper temperature-controlled iron will be quite a lot more expensive - retailing at say £40 (US$ 60) or more - and will have some form of built-in thermostatic control, to ensure that the temperature of the bit (the tip of the iron) is maintained at a fixed level (within limits). This is desirable especially during more frequent use, since it helps to ensure that the temperature does not "overshoot" in between times, and also guarantees that the output will be relatively stable. Some irons have a bimetallic strip thermostat built into the handle which gives an audible "click" in use: other types use all-electronic controllers, and some may be adjustable using a screwdriver.

Yet more expensive still, ***soldering stations*** cost from £70 (US$ 115) upwards (the iron may be sold separately, so you can pick the type you prefer), and consist of a complete bench-top control unit into which a special *low-voltage* soldering iron is plugged. Some versions might have a built-in digital temperature readout, and will have a control knob to enable you to vary the setting. The temperature could be boosted for soldering larger joints, for example, or for using higher melting-point solders (e.g. silver solder). These are designed for the most discerning users, or for continuous production line/ professional

use. The best stations have irons which are well balanced, with comfort-grip handles which remain cool all day. A thermocouple will be built into the tip or shaft, which monitors temperature.

Anti-static protection: if you're interested in soldering a lot of static-sensitive parts (e.g. CMOS chips or MOSFET transistors), more advanced and expensive soldering iron stations use static-dissipative materials in their construction to ensure that static does not build up on the iron itself. You may see these listed as "ESD safe" *(electrostatic discharge proof)*. The cheapest irons won't necessarily be ESD-safe but never the less will still probably perform perfectly well in most hobby or educational applications, if you take the usual anti-static precautions when handling the components. The tip would need to be well earthed (grounded) in these circumstances.

Bits: it's useful to have a small selection of manufacturer's bits (soldering iron tips) available with different diameters or shapes, which can be changed depending on the type of work in hand. You'll probably find that you become accustomed to, and work best with, a particular shape of tip. Often, tips are *iron-coated* to preserve their life, or they may be bright-plated instead. Copper tips are seldom seen these days.

Spare parts: it's nice to know that spare parts may be available, so if the element blows, you don't need to replace the entire iron. This is especially so with expensive irons. Check through some of the larger mail-order catalogues.

A ***solder gun*** is a pistol-shaped iron, typically running at 100W or more, and is completely unsuitable for soldering modern electronic components: they're too hot, heavy and unwieldy for micro-electronics use. Plumbing, maybe..!

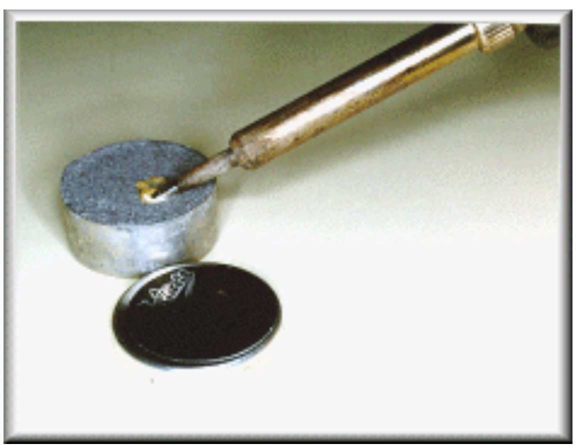
Soldering irons are best used along with a heat-resistant ***bench-type holder***, so that the hot iron can be safely parked in between use. Soldering stations already have this feature, otherwise a separate soldering iron stand is essential, preferably one with a holder for tip-cleaning sponges. Now let's look at how to use soldering irons properly, and how to put things right when a joint goes wrong.

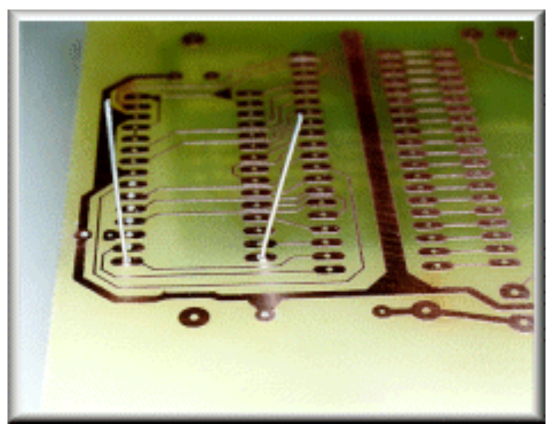
The Basic Soldering Guide Photo Gallery

Soldering is a delicate manual skill which only comes with practice. Remember that your ability to solder effectively will determine directly how well the prototype or product functions during its lifespan. Poor soldering can be an expensive business - causing product failure and downtime, engineer's maintenance time and customer dissatisfaction. At hobbyist level, bad soldering technique can be a cause of major disappointment which damages your confidence. It needn't be like that: soldering is really easy to learn, and like learning to ride a bike, once mastered is never forgotten!

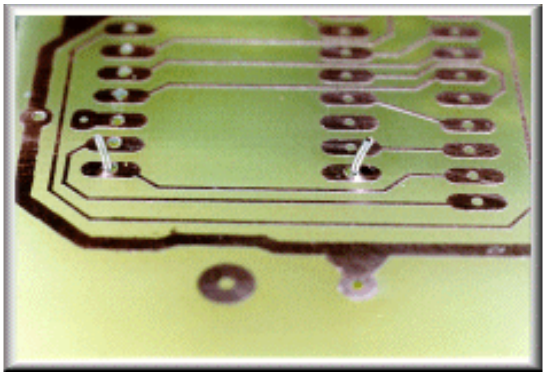
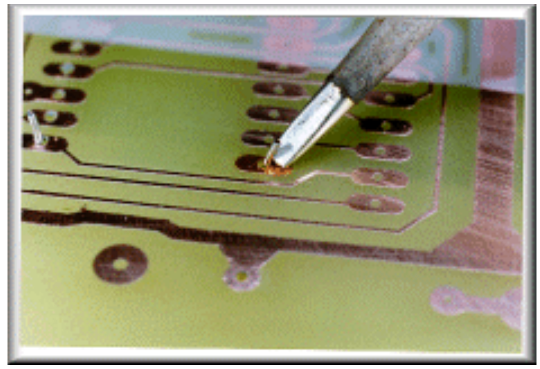
These photos illustrate the basic steps in making a perfect solder joint on a p.c.b. If you're a beginner, our advice is that it's best to practice your soldering technique using some clean, new parts with perhaps some new stripboard (protoboard). Be sure to avoid using old, dirty parts; these can be difficult if not impossible to solder.

(Left) Printed circuit board copper tracks must be clean to begin with, especially if they're not previously "tinned" with solder. Clean any raw p.c.b. copper tracks gently with e.g. an abrasive rubber block available from electronics suppliers. **(Right)** Clean the iron "bit" (soldering iron tip) using a damp sponge. The soldering iron featured is an Ungar Concept 2100 Soldering Station. Other popular brands of soldering equipment include Weller and Antex.

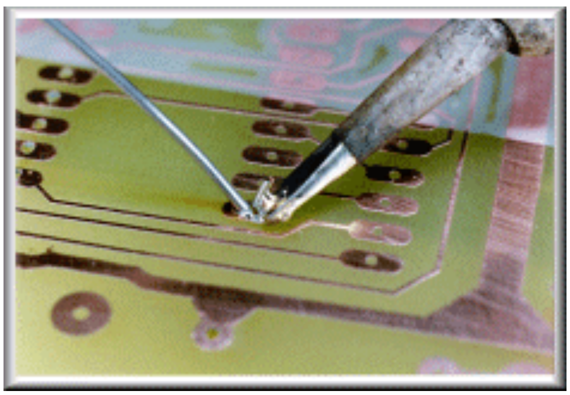
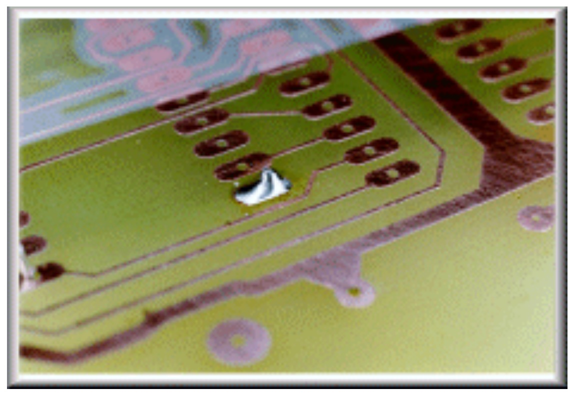




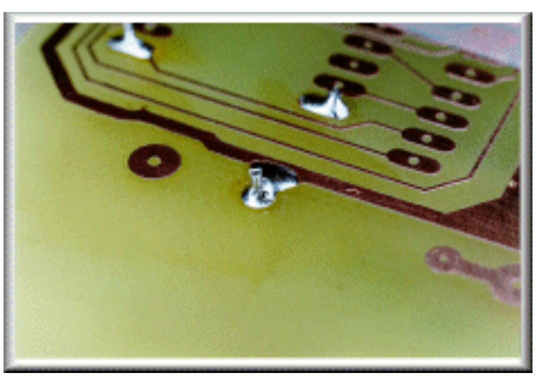
(Left) A useful product is Multicore's Tip Tinner Cleaner (TTC) - a 15 gramme tin of special paste which cleans and "tins" the soldering iron iron, in one go. New tips must be tinned **immediately** when used for the first time.   **(Right)** Insert components and splay the leads so that the part is held in place.

(Left) It's usually best to snip the electronic component wires to length prior to soldering. This helps prevent transmitting mechanical shocks to the copper foil.**(Right)** Apply a clean soldering iron tip to the copper solder pad and the component lead, in order to heat *both* items at the same time.

(Left) Continue heating and apply a few millimetres of solder. Remove the iron and allow the solder joint to cool naturally. **(Right)** It only takes a second or two, to make the perfect joint, which should be nice and shiny. Check the Guide for troubleshooting help.



An example of a "dry" or "gray" soller joint - the solder failed to flow, and instead beaded to form globules around the wire.

How to solder

Turning to the actual techniques of soldering, firstly it's best to *secure the work* somehow so that it doesn't move during soldering and affect your accuracy. In the case of a printed circuit board, various holding frames are fairly popular especially with densely populated boards: the idea is to insert all the parts on one side ("stuffing the board"), hold them in place with a special foam pad to prevent them falling out, turn the board over and then snip off the wires with cutters before making the joints. The frame saves an awful lot of turning the board over and over, especially with large boards. Other parts could be held firm in a modeller's small vice, for example.

Solder joints may need to possess some degree of mechanical strength in some cases, especially with wires soldered to, say, potentiometer or switch tags, and this means that the wire should be looped through the tag and secured before solder is applied. The down side is that it is more difficult to *de-solder* the joint (see later) and remove the wire afterwards, if required. Otherwise, in the case of an ordinary circuit board, components' wires are bent to fit through the board, inserted flush against the board's surface, splayed outwards a little so that the part grips the board, and then soldered.

In my view - opinions vary - it's generally better to snip the surplus wires leads off *first*, to make the joint more accessible and avoid applying a mechanical shock to the p.c.b. joint. However, in the case of semiconductors, I often tend to leave the snipping until *after* the joint has been made, since the excess wire will help to sink away some of the heat from the semiconductor junction. Integrated circuits can either be soldered directly into place if you are confident enough, or better, use a dual-in-line socket to prevent heat damage. The chip can then be swapped out if needed.

Parts which become hot in operation (e.g. some resistors), are raised above the board slightly to allow air to circulate. Some components, especially large electrolytic capacitors, may require a mounting clip to be screwed down to the board first, otherwise the part may eventually break off due to vibration.

The perfectly soldered joint will be nice and shiny looking, and will prove reliable in service. I would say that:

- cleanliness
- temperature
- time
- adequate solder coverage

are the key factors affecting the quality of the joint. A little effort spent now in soldering the perfect joint may save you - or somebody else - a considerable amount of time in troubleshooting a defective joint in the future. The basic principles are as follows.

Really Clean

First, and without exception, all parts - including the iron tip itself - must be clean and free from contamination. Solder just will not "take" to dirty parts! Old components or copper board can be notoriously difficult to solder, because of the layer of oxidation which builds up on the surface of the leads. This repels the molten solder and this will soon be evident because the solder will "bead" into globules, going everywhere except where you need it. Dirt is the enemy of a good quality soldered joint!

Hence, it is an absolute necessity to ensure that parts are free from grease, oxidation and other contamination. In the case of old resistors or capacitors, for example, where the leads have started to oxidise, use a small hand-held file or perhaps scrape a knife blade or rub a fine emery cloth over them to reveal fresh metal underneath. Stripboard and copper printed circuit board will generally oxidise after a few months, especially if it has been fingerprinted, and the copper strips can be cleaned using an abrasive rubber block, like an aggressive eraser, to reveal fresh shiny copper underneath.

Also available is a fibre-glass filament brush, which is used propelling-pencil-like to remove any surface contamination. These tend to produce tiny particles which are highly irritating to skin, so avoid accidental contact with any debris. Afterwards, a wipe with a rag soaked in cleaning solvent will remove most grease marks and fingerprints. After preparing the surfaces, avoid touching the parts afterwards if at all possible.

Another side effect of having dirty surfaces is the tendency for people to want to apply *more heat* in an attempt to "force the solder to take". This will often do more harm than good because it may not be possible to burn off any contaminants anyway, and the component may be overheated. In the case of semiconductors, temperature is quite critical and they may be harmed by applying such excessive heat.

Before using the iron to make a joint, it should be "tinned" (coated with solder) by applying a few millimetres of solder, then wiped on a damp sponge preparing it for use: you should always do this immediately with a new bit, anyway. Personally, I always re-apply a very small amount of solder again, mainly to improve the thermal contact between the iron and the joint, so that the solder will flow more quickly and easily. It's sometimes better to tin larger parts as well before making the joint itself, but it isn't generally necessary with p.c.b. work. (All *EPE* printed circuit boards are "roller-tinned" to preserve their quality and to help with soldering.) A worthwhile product is Weller's *Tip Tinner & Cleaner*, a small 15 gram tinlet of paste onto which you dab a hot iron - the product cleans and tins the iron ready for use. An equivalent is Adcola *Tip-Save*.

Normal electronics grade solder is now "lead free" and typically contains Sn 97 Ag 2.5 Cu 0.5 (i.e. 97% tin, 2.5% silver and 0.5% copper). **It already contains cores of "flux"** which helps the molten solder to flow more easily over the joint. Flux removes oxides which arise during heating, and is seen as a brown fluid bubbling away on the joint. The use of separate acid flux paste (e.g. as used by plumbers) should NEVER be necessary in normal electronics applications because electronics-grade solder already contains the correct grade of flux! Other solders are available for specialist work, including

aluminium and silver-solder. Different solder diameters are produced, too; 20-22 SWG (19-21 AWG) is 0.91-0.71mm diameter and is fine for most work. Choose 18 SWG (16 AWG) for larger joints requiring more solder.

Temperature

Another step to successful soldering is to ensure that the **temperature** of *all* the parts is raised to roughly the same level before applying solder. Imagine, for instance, trying to solder a resistor into place on a printed circuit board: it's far better to heat *both* the copper p.c.b. *and* the resistor lead at the same time before applying solder, so that the solder will flow much more readily over the joint. Heating one part but not the other is far less satisfactory joint, so strive to ensure that the iron is in contact with *all* the components first, before touching the solder to it. The melting point of most solder is in the region of 188°C (370°F) and the iron tip temperature is typically 330-350°C (626°-662°F). The latest lead-free solders typically require a higher temperature.

Now is the time

Next, the joint should be heated with the bit for just the right amount of time - during which a short length of solder is applied to the joint. Do not use the iron to carry molten solder over to the joint! Excessive time will damage the component and perhaps the circuit board copper foil too! Heat the joint with the tip of the iron, then continue heating whilst applying solder, then remove the iron and allow the joint to cool. This should take only a few seconds, with experience. The heating period depends on the temperature of your iron and size of the joint - and larger parts need more heat than smaller ones - but some parts (semiconductor diodes, transistors and i.c.s), are sensitive to heat and should not be heated for more than a few seconds. Novices sometimes buy a small clip-on heat-shunt, which resembles a pair of aluminium tweezers. In the case of, say, a transistor, the shunt is attached to one of the leads near to the transistor's body. Any excess heat then diverts up the heat shunt instead of into the transistor junction, thereby saving the device from over-heating. Beginners find them reassuring until they've gained more experience.

Solder Coverage

The final key to a successful solder joint is to apply an appropriate amount of solder. Too much solder is an unnecessary waste and may cause short circuits with adjacent joints. Too little and it may not support the component properly, or may not fully form a working joint. How much to apply, only really comes with practice. A few millimetres only, is enough for an "average" p.c.b. joint, (if there is such a thing).

Here's a summary of how to make the perfect solder joint.

1. All parts must be clean and free from dirt and grease.
2. Try to secure the work firmly.
3. "Tin" the iron tip with a small amount of solder. Do this immediately, with new tips being used for the first time.
4. Clean the tip of the hot soldering iron on a damp sponge.
5. Many people then add a tiny amount of fresh solder to the cleansed tip.

6. Heat all parts of the joint with the iron for under a second or so.
7. Continue heating, then apply sufficient solder only, to form an adequate joint.
8. Remove and return the iron safely to its stand.
9. It only takes two or three seconds at most, to solder the average p.c.b. joint.
10. Do not move parts until the solder has cooled.

Troubleshooting Guide

- Solder won't "take" - grease or dirt present - desolder and clean up the parts. Or, material may not be suitable for soldering with lead/tin solder (eg aluminium).
- Joint is crystalline or grainy-looking - has been moved before being allowed to cool, or joint was not heated adequately - too small an iron/ too large a joint.
- Solder joint forms a "spike" - probably overheated, burning away the flux.

Desoldering methods

A soldered joint which is improperly made will be electrically "noisy", unreliable and is likely to get worse in time. It may even not have made any electrical connection at all, or could work initially and then cause the equipment to fail at a later date! It can be hard to judge the quality of a solder joint purely by appearances, because you cannot say how the joint actually formed on the *inside*, but by following the guidelines there is no reason why you should not obtain perfect results.

A joint which is poorly formed is often called a "dry joint". Usually it results from dirt or grease preventing the solder from melting onto the parts properly, and is often noticeable because of the tendency of the solder not to "spread" but to form beads or globules instead, perhaps partially. Alternatively, if it seems to take an inordinately long time for the solder to spread, this is another sign of possible dirt and that the joint may potentially be a dry one.

There will undoubtedly come a time when you need to *remove* the solder from a joint: possibly to replace a faulty component or fix a dry joint. The usual way is to use a ***desoldering pump*** or vacuum pump which works like a small spring-loaded bicycle pump, only in reverse! (More demanding users using CMOS devices might need a pump which is ESD safe.) A spring-loaded plunger is released at the push of a button and the molten solder is then drawn up into the pump. It may take one or two attempts to clean up a joint this way, but a small desoldering pump is an invaluable tool especially for p.c.b. work.

Sometimes, it's effective to actually *add more* solder and then desolder the whole lot with a pump, if the solder is particularly awkward to remove. Care is needed, though, to

ensure that the boards and parts are not damaged by excessive heat; the pumps themselves have a P.T.F.E. nozzle which is heat proof but may need replacing occasionally.

An excellent alternative to a pump is to use *desoldering braid*, including the famous American "Soder-Wick" (sic) or Adcola "TISA-Wick" which are packaged in small dispenser reels. This product is a specially treated fine copper braid which draws molten solder up into the braid where it solidifies. The best way is to use the tip of the hot iron to press a short length of braid down onto the joint to be de-soldered. The iron will subsequently melt the solder, which will be drawn up into the braid. Take extreme care to ensure that you don't allow the solder to cool with the braid adhering to the work, or you run the risk of damaging p.c.b. copper tracks when you attempt to pull the braid off the joint. See my photo gallery for more details.

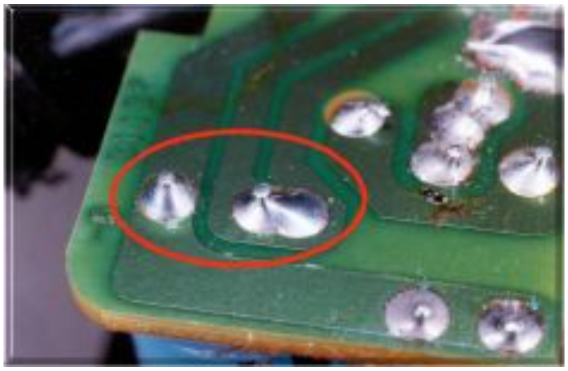
I recommend buying a small reel of de-soldering braid, especially for larger or difficult joints which would take several attempts with a pump. It is surprisingly effective, especially on difficult joints where a desoldering pump may prove a struggle.

The Basic De-soldering Guide Photo Gallery (and Black Museum of Bad Soldering)

De-soldering is required when electronic components need to be removed from a circuit, usually because they are faulty. It may sometimes be necessary during testing or assembly, if a wrong part has been fitted or a modification has to be made. In the field, it's not uncommon for faulty electronic components to be swapped out, or poor joints (perhaps "dry" or gray joints) to need re-making properly, months or years after manufacture. Experienced engineers can often diagnose a particular faulty joint immediately, because they may have seen the same problem on similar electronic equipment before, especially if the equipment has a "reputation". A proper desoldering technique can soon be acquired with practice - all you need to do is buy some scrap boards to have a go with, and desolder to your heart's content!

The next photo sequence illustrates the basic steps for desoldering a printed circuit board, in order to remove a faulty part. Both the technique for using a desoldering suction pump as well as desolder braid are illustrated. Some real-life examples of poor soldering are shown too, in my *Black Museum of Bad Soldering*!

Remember - it costs just as much to get it right as it does to get it wrong! Practice makes perfect.



(Left) The two solder joints to be desoldered, to enable a faulty electrolytic capacitor to be removed from the printed circuit board.

(Right) If using a suction-type desoldering pump, apply the soldering iron tip first to melt the solder joint (say for 1-2 seconds). Ensure the spring-loaded desoldering pump is 'primed' and ready to go...

(Left) The PTFE nozzle of the desoldering pump is applied to the molten solder and the spring-loaded plunger is then immediately released, drawing the molten solder up into the pump. Remove the soldering iron tip. Repeat the process if needed. *Handy tip*: sometimes it helps to add some fresh solder and then desolder the whole joint.

(Right) The first p.c.b. joint, now desoldered. The second joint will be desoldered using traditional desoldering braid.

(Left) Select a suitable width of desoldering braid, and **press it down** onto the **COLD** joint using the hot tip of the iron. A flat soldering iron bit is preferable.

(Right) The molten solder is drawn up by capillary action into the desoldering braid. Take care not to overheat the board (the p.c.b. copper track may lift off), nor 'drag whiskers' of solder over the board, nor let the braid solidify onto the joint! Remove the braid while the joint is still molten.

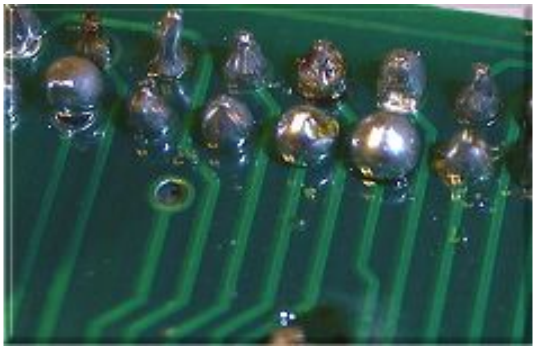
 

(Left) The faulty electrolytic capacitor dropped out of the board after desoldering. Sometimes, it may need persuading with pliers.... but don't overdo this or you risk damaging the copper tracks on the p.c.b.

(Right) Close-up photograph of both joints, now desoldered and ready for the replacement component to be fitted.

The Black Museum of Bad Soldering

These are all genuine examples which have not been retouched or reworked in any way.

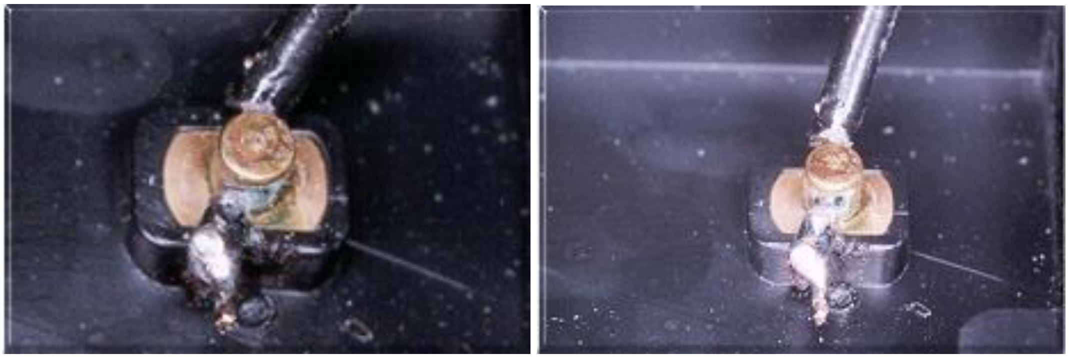



(Left) A tenfold excess of solder on this hand-soldered printed circuit board, and (extreme left) an incomplete solder joint with poor coverage. There is no need to add more solder "for luck".

(Right) An example of a dry (or gray) solder joint found inside a commercial PSU for a computer peripheral. The wire had been fed through the hole in the brass terminal, and merely tacked on with a blob of solder. This is a fire hazard (risk of arcing and overheating).


(Left) Hmmmm... this joint looks somewhat suspect as well... it's the earth (ground) wire in the same PSU

(Right) A close-up reveals the terrible standard of soldering (and quality control), with a fracture visible on this ground/ earth joint.



(Left) How **not** to make a mains voltage soldered joint. This solder joint went "dry" and starting arcing, nearly destroying the attached equipment. It is also a fire hazard.

(Right) The same mains connection, the wire merely being 'tacked on' with a blob of solder.

First Aid

If you are unlucky enough to receive burns which require treatment, here's what to do :-

1. Immediately cool the affected area with cold running water for several minutes.
2. Remove any rings etc. before swelling starts.
3. Apply a sterile dressing to protect against infection.
4. Do not apply lotions, ointments etc., nor prick any blisters which form later.
5. Seek professional medical advice where necessary.

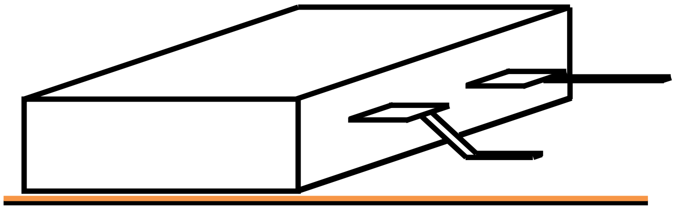
A Few Hints about soldering on a Ground Plane

Before starting

- Always remove any grease and water from your hands. This will reduce the extent to which you oxidise and contaminate the board.
- Avoid touching the copper surface with your hands, always hold a board by its edges.
- Ensure all power and signal inputs are turned off (the soldering iron will short anything you touch to ground!!!)

Soldering a component

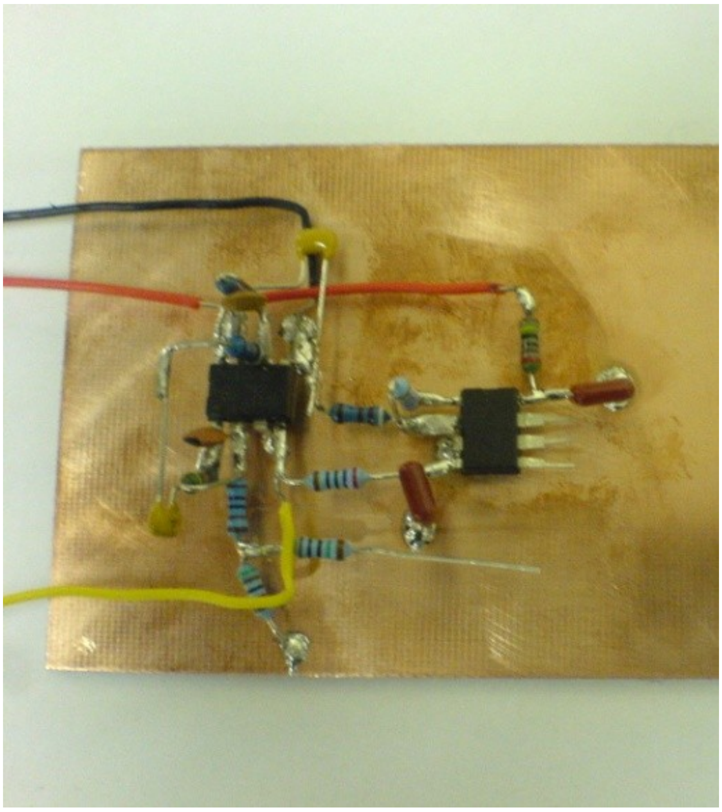
- Consider the circuit pathway from input to output in order to minimise the distance. This is especially important between ICs.
- Use the cleaning rubbers or solutions to clean away the oxidised surface where you are going to mount the component. This will help improve the electrical characteristic and improve solder flow
- Where you intend to place solder, VERY LIGHTLY scratch a cross-hatch pattern on the copper plate with a sharp tool. This will increase the friction thereby preventing your soldering iron skating across the board surface
- Apply heat to the copper surface first then add the solder so it smoothly flows on to the copper.
- Use pliers to bend the wire/chip legs to form small feet as this will increase the stability and make them much easier to solder. All wire bends should be done with pliers!
- Tin the legs before trying to mount them on the board
- When using wire, devise a colour coding system and stick to it i.e. red +ve rail, black GND rail, yellow –ve rail, blue input etc. This will make debugging so much easier
- If you are soldering an IC, two good techniques are:
    - Bend its legs with pliers so they are all horizontal and the chip can sit flat on the GND plane surface. Then place a bend just after where the pin leg narrows and bend again slightly further down so the leg it touching the ground plane (see image below). This way the IC is firmly held in place.



    - Bend legs touching the copper plane at the end to make small feet, then bend all other legs so that they are horizontal. This will result in the chip hovering just off the GND plane reducing the stability, but increasing the space to connect further components.
- Keep component leads as short as possible. This will reduce parasitics, improve mechanical robustness and reduce the chance of accidental shorts

These rules should be followed in conjunction with Dr Clarke's Soldering Guidelines found on the EE2 lab website.

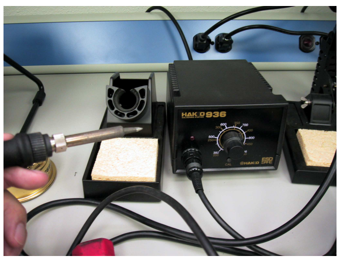
Here is a good copper board layout. Notice the neat leads with none left loose above the circuit, and the way that the layout looks like a schematic. See the web copy (on the AMP handout page) of this picture for more detail.



Soldering and Desoldering Instruction

Soldering is defined as "the joining of metals by a fusion of alloys which have relatively low melting points". In other words, you use a metal that has a low melting point to adhere the surfaces to be soldered together. Soldering is more like gluing with molten metal than anything else. Soldering is also a must have skill for all sorts of electrical and electronics work. It is also a skill that must be taught correctly and developed with practice.

Remember that when soldering, the rosin in the solder releases fumes. These fumes are harmful to your eyes and lungs. Therefore, always work in a well-ventilated area. Hot solder is also dangerous. Be sure not to let is splash around because it will burn you almost instantly. Eye protection is also advised.



The Tools

Soldering Iron – Even the cheapest of them will do the job. They may not last as long, but they do get hot enough to melt solder and that is the goal. You only need to make sure that the one you buy has a suitable tip on it. The most typical tip is the one that is about the size of a 1/8" stereo mini-plug.

Solder – Get Rosin Core solder. Rosin will help the solder to flow onto the wires. Solder comes in different thickness. Buy what is appropriate for your job.

Desoldering Gun – This tool will make life a lot easier when you need to rework a previous solder job.
Solder Wick – Braided copper with rosin coating used to draw solder off of circuit boards.

SMD Rework station— Basically this is a high temp hair dryer with special nozzle attached. It heats up entire pins of the SMD device so you can remove them.

The Methods

Soldering – There is not art to soldering, it takes patience and practice to get it right. If you are doing it right, it will be easy and very fast. First, make sure that your soldering iron tip is clean. If it is dirtier than just a light gray color, you need to clean it. You can do this with sandpaper or a Scotch Brite pad. Next, turn your iron on and give it plenty of time to heat up. To test the heat, use a piece of solder touched to the tip. If it melts immediately, it is ready.

The most common way to mess up a solder job is to let the soldering iron stay on the parts to be soldered too long. What this does is oxidize the metal, making it too dirty to attract solder. If you are working with a circuit board, too much heat can damage the board, rendering it useless and in need of repair. You should only hold the soldering iron to the parts to be joined for no more than 10-12 seconds. Any longer and you will melt insulation on wire or damage a circuit board.

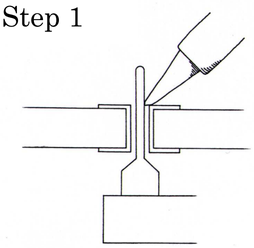
It has been said that soldering is a two-person job. You need two hands to hold the parts together, one hand to hold the iron, and another to feed the solder. The correct method for applying solder is to hold the joint perfectly still while heating with the soldering iron. After a few seconds, introduce the end of the solder at the point where the iron meets the parts

If the solder does not melt immediately and flow onto the joint, pull the solder away and try again after a couple seconds longer. If you exceed 10 seconds, pull the iron off and try again after it all cools down. You probably didn't have the iron touching enough of the parts to be soldered. Sometimes, the parts to be soldered are so big that they conduct the heat away very quickly and make it difficult to solder. In this case, it is OK to put some solder on each part individually and then put them together later by melting the solder on each one while they are touching.

Joining Two Wires - Strip off about 3/8" of insulation from the two wire ends to be joined. Place a ½" length of heat shrink tubing over one wire and push it back so that the heat from soldering won't shrink it prematurely. Fold each bare wire end back on itself so that the tip of the wire now comes back to the end of the insulation. Link both wires together using the bends like hooks. Now, twist the ends of the wires around themselves tightly. This type of connection is called a Western Union and it is the strongest method of joining two wires together. Now, heat the connection with the iron and allow solder to flow over the entire joint. Wait a few seconds for it to cool off and then slide the heat shrink tubing down over the connection and heat it with a match or heat gun.

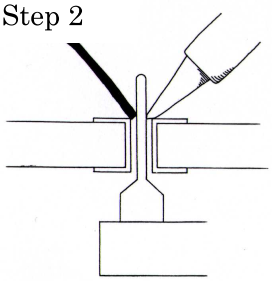
Soldering a Wire to a Circuit Board – This is delicate work that you will do while soldering. Too much heat and your board will be damaged. If you are attaching a wire to an existing hole on the board, make sure that the hole is clean and free of any excess solder (see de-soldering for more detail). The best advice when soldering to a circuit board is to angle your soldering iron tip so that it makes good contact with the pad on the circuit board and the wire or part to be soldered at the same time. Heat the parts up and touch the solder at the point where the tip meets the part and the pad. If the solder does not flow immediately, pull everything off and wait for it to cool down and try again later.

Step 1



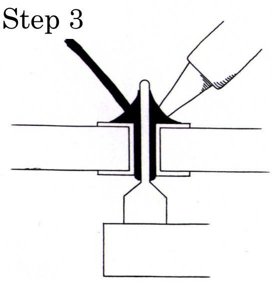
Apply heat to both pin and pad on the circuit board. Make sure tip of the soldering iron is touching both pin and pad.

Step 2



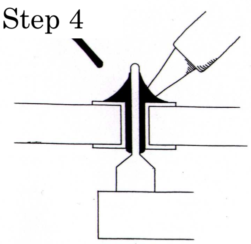
When the both pin and pad are heated enough, apply solder to the pin and pad. Solder should starts to flow.

Step 3



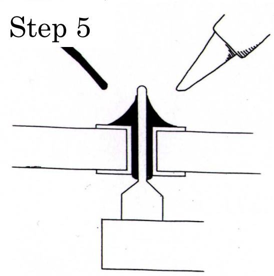
Apply enough but not too much solder. While applying the solder, do not move the tip of iron.

Step 4



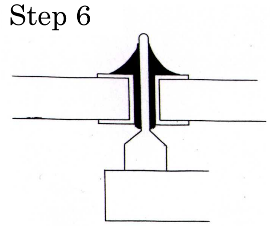
Remove solder away.

Step 5



Remove tip of soldering iron also.

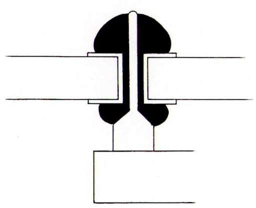
Step 6



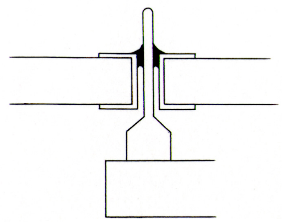
Done! Check the joint to make sure the connection.

Good soldering and Bad soldering Joints

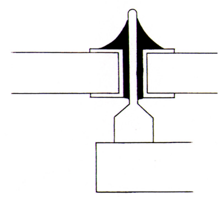
Here are some example of Good soldering and Bad soldering joint.
For Japanese, we often say, “Good soldering joint should look like Mt. Fuji.”



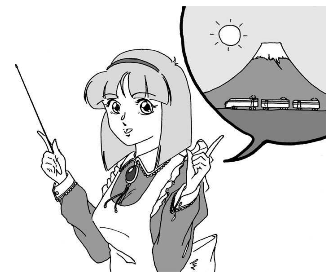
Too much soldering



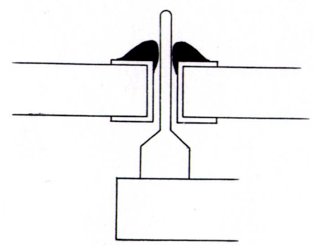
Too little soldering



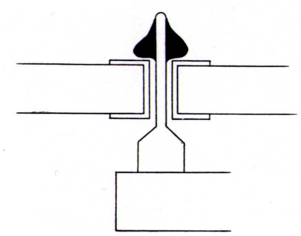
Good soldering



Cold Solder Joints
A cold joint is a joint in which the solder does not make good contact with the component lead or printed circuit board pad. Cold joints occur when the component lead or solder pad moves before the solder is completely cooled. Cold joints make a really bad electrical connection and can prevent your circuit from working.
Cold joints can be recognized by a characteristic grainy, dull gray color, and can be easily fixed. This is done by first removing the old solder with a desoldering tool or simply by heating it up and flicking it off with the iron. Once the old solder is off, you can re-solder the joint, making sure to keep it still as it cools.



Cold soldering joints



Tips and Tricks

Soldering is something that needs to be practiced. These tips should help you become successful so you can stop practicing and get down to some serious building.

1. Use heat sinks. Heat sinks are a must for the leads of sensitive components such as ICs and transistors. If you don't have a clip on heat sink, then a pair of pliers is a good substitute.

2. Keep the iron tip clean. A clean iron tip means better heat conduction and a better joint. Use a wet sponge to clean the tip between joints.

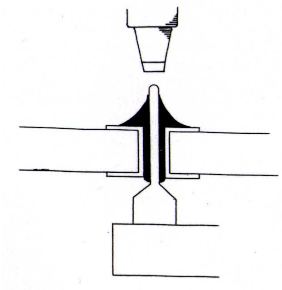
3. Double-check joints. It is a good idea to check all solder joints with an ohmmeter after they are cooled. If the joint measures any more than a few tenths of an ohm, then it may be a good idea to re-solder it.

4. Use the proper iron or temperature. Remember that bigger joints will take longer to heat up with an 30W iron than with a 150W iron. While 30W is good for printed circuit boards and the like, higher wattages are great when soldering to a heavy metal chassis.

Desoldering

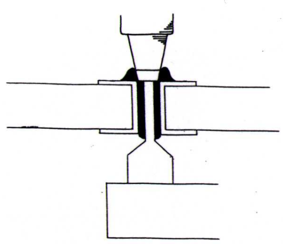
Desoldering is extremely difficult compare to soldering. In the process of RomBoard installation, the parts and circuit board must be in the good shape to re-use them. The tool we use is Desoldering Gun. This device has vacuum pump built in with heater tip. Process of desoldering it self is very simple, but there are some tricks to do clean and safe desoldering job.

Step 1



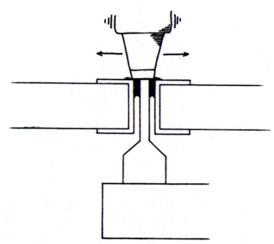
Put the desoldering gun's tip over to the soldering joint. Make sure nozzle is 90° angle from circuit board.

Step 2



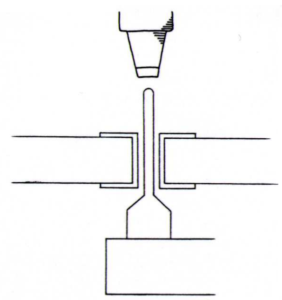
Apply the enough heat to melt entire solder. Multi-layer board or ground pin may take while to transfer heat.

Step 3



While applying vacuum, move the tip around the pin to get all the solder of around the pin out. At this time, you can also feel pin moves freely, so you know pin is free from circuit board.

Step 4

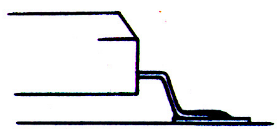


When you can hear air flow sound from hole, you should be done. Stop applying vacuum and remove the gun from the pin. Inspect hole and pin.

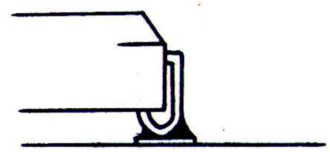
When you done with desoldering, the parts that you are trying to remove should move freely. If it doesn't, find which pin is still has solder left, and re-apply fresh solder to it and try desoldering process again. The multi-layer circuit board require more heat to get solder to melt. Make sure pin start to move freely by moving the tip of soldering gun before you apply vacuum to it.

SMD device soldering and removal

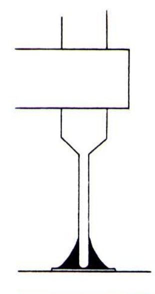
In the process of RomBoard installation, chance of handling SMD devices is becoming higher and higher due to ECU configuration change.
Soldering of SMD devices are not much different from regular through hole soldering.
Important thing is positioning of the device is very critical.
Start with applying little solder to two of the each corner of the pads on the circuit board.
Then, place the SMD device and re-heat a one of the solder you just applied to connect a SMD device pin to the pad. Check the position of the device, if position is right re-heat the other end of solder to secure the device completely. If you didn't get position right, re-heat the pin that you just soldered and while heating a pin, move the device to the right position.
Once you positioned the device in the right position, apply Rosin Flux to both pins and pads. This will help your soldering job by keeping solder separate from each pin.
Here is how the joint on SMD device pin should look like.



QFP and SOP chip

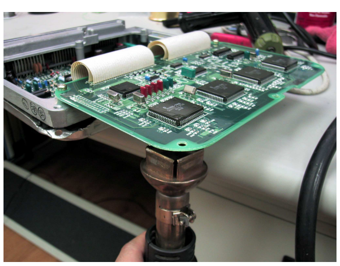


PLCC chip

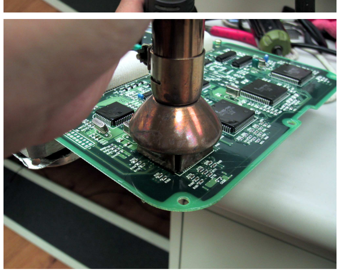


RomBoard adapter socket

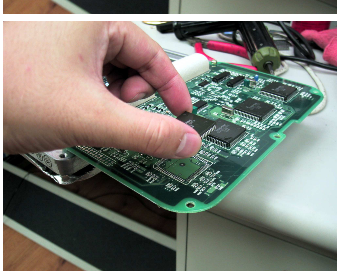
Removing SMD device will be the probably the most difficult process. SMD rework station is used to do this. Make sure all the pins are completely heated otherwise you will be removing a pad from the circuit board along with device. Also, you should note, when you are applying heat to the device, some parts around the device is also heated and moves around when you touch. It is good idea to take a note of location of the devices near the target device.



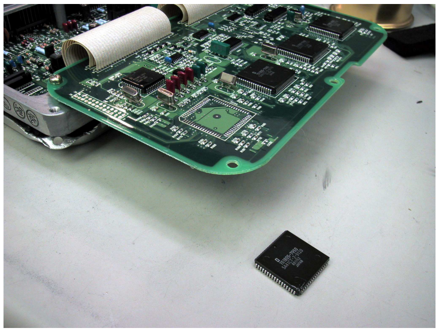
Step 1
Apply pre-heat from back side of the target device. Keep applying heat until you can't touch the chip. By this time, circuit board should have enough heat.



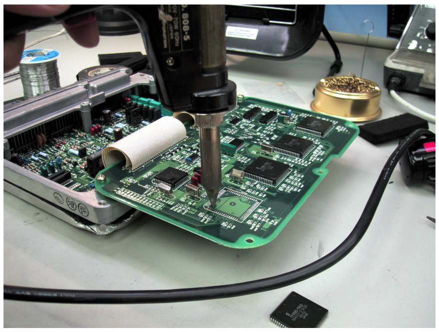
Step 2
Apply heat from top of the target device. Nozzle should cover entire chip. You can check if chip is free from solder by sliding the nozzle left and right. Make sure you don't move other parts. If the chip moves freely, it is ready to be removed.



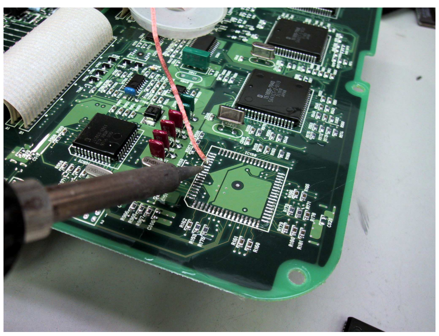
Step 3
Remove the chip straight up to avoid making solder bridge between pins. Chip is extremely hot! Unless you have skin of steel, avoid imitating the picture.



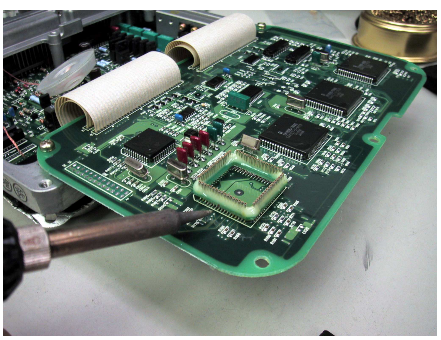
Step 4
After remove the chip, cool down both circuit board and chip.



Step 5
Clean the pads on the circuit board with desoldering gun.
Do not apply too much heat to the pad. Pad might peel off from circuit board. Clean the chip by desoldering gun also.
Check for any bridge between pins. If the chip has too much protective coating on it, use solvent to clean it up.



Step 6
If the pads on the circuit board is too small to use desolding gun, try cleaning by solder wick with rosin flux. This may take time but it is much better than peeling pads off.
Once again, do not apply too much heat.



Step 7
Solder the RomBoard adapter where the chip was.
Refer SMD device soldering section for how to solder adapter.

The Final Word

Soldering, desoldering, and working with SMD device will take some effort to learn. You should be relaxed and concentrated when you work.
Keeping every thing clean (tip of iron, gun, work surface, etc) will help you also.
Once you get comfortable to work with soldering you may find your own tips and tricks.
Experience is all bout soldering.

EOF

Strain Gages and Instruments | Tech Tip TT-609

Strain Gage Soldering Techniques

Introduction

The most common method of making electrical connections in strain gage circuits is by means of soft solders, in wire form. Other methods, such as spot welding, brazing, compression bonding, paste solders, and conductive epoxies, are also available, but find only limited application. Solders have many advantages for strain gage use — they are low in cost, readily available in various alloy compositions to provide a range of melting temperatures, and are easily obtained in the form of either solid wire or wire with a core of flux. They are convenient to use, and offer an excellent combination of electrical and mechanical properties.

Although soldering is basically a simple procedure, it must be done with appropriate tools, supplies, and techniques to assure accurate strain measurement. This is particularly true when test requirements are severe in the sense of approaching the limits of the strain gage circuit capabilities; e.g., long-term stability, high-elongation measurements, fatigue endurance, etc. Use of improper materials or techniques can significantly degrade strain gage performance.

The purpose of this Tech Tip is to outline recommended procedures and materials for attaching leadwires to strain gage solder tabs or to bonded printed-circuit terminals. These reliable, experience-proven methods are based on the use of a professional quality soldering station, in conjunction with Micro-Measurements solders and installation accessories.

Soldering Station and Pencil

For precision soldering of strain gages, it is always necessary to use a temperature- or power-controlled soldering station that provides low voltage and adjustable temperature to the soldering iron tip. An unregulated soldering iron, connected directly to the power line, is not ordinarily suitable for strain gage use because the tip temperature is apt to be far too high. This tends to oxidize the tip, and to instantly vaporize the flux, making soldering much more difficult. In addition, the unnecessarily high temperature may damage the strain gage, the bonding adhesive, or even the test specimen. For these reasons, the soldering station should incorporate provision for adjusting the soldering temperature to suit varying installation conditions and requirements. The temperature must be adjusted, of course, to accommodate the melting points of the different solders commonly used for strain gage connections, but also to allow for environmental conditions such as drafts or outdoor soldering in cold weather. Moreover, the temperature controller should be carefully designed to ensure that it does not generate electrical noise that could adversely affect nearby measuring instruments when both are in use.

Design of the soldering pencil also requires special consideration. It should be light in weight, with a very flexible power cord, and with the gripping area thermally insulated from the heating element. These characteristics contribute to the comfort, ease, and precision of soldering, and minimize operator fatigue during long periods of use. The soldering tip itself should be of the flat, chisel, or screwdriver type. Pointed tips should not be used, because they tend to draw solder away from the work area, and thus make it more difficult to achieve a proper joint. In contrast, flat tips act to confine the solder, while offering greater surface area for better heat transfer and more effective soldering, generally.

Micro-Measurements soldering units incorporate all of the above features and a number of others, designed to help the user easily make consistent, reliable solder joints. These soldering units are widely used by professional strain gage installers everywhere, in both stress analysis laboratories and in transducer manufacture.

Solder Selection

The Micro-Measurements Division stocks a broad range of solder types to meet various installation and test requirements. While solders are sometimes selected to provide specific electrical or mechanical properties, the most common basis for selection is simply the melting-temperature range. Low-melting-point solders, for example, are generally used for strain gage installations on nonmetallic test parts to avoid damaging the gage, bonding adhesive, or test material due to overheating. In contrast, high-temperature solders are normally selected only when necessary to satisfy elevated-temperature testing requirements. These solders are somewhat more difficult to handle because the higher working temperature

Strain Gage Soldering Techniques

rapidly vaporizes the flux, and oxidizes the soldering tip, both of which tend to impede the soldering process. Specially designed soldering tips are recommended for high-temperature use.

For routine applications, where test conditions do not dictate the use of either a low- or high-temperature solder, an alloy with an intermediate melting temperature is the normal selection. The 63/37 tin-lead alloy (Type 361A-20R) is an excellent choice for general-purpose strain gage soldering. As an eutectic alloy, it has a sharply defined melting temperature — a characteristic that largely eliminates “cold” solder joints. The addition of a trace of antimony provides superior performance when the soldered connections will be exposed to very low (cryogenic) temperatures for long periods of time.

The general-purpose solders are supplied with a core of activated rosin flux. This makes soldering much more convenient, and is particularly useful in field applications where accessory liquid rosin flux (M-Flux AR) may not be available. Solid-wire solder, with externally applied acid flux (M-Flux SS), is recommended for making soldered connections to Micro-Measurements K- and D-alloy (modified Karma and isoelastic) strain gages. Rosin-core solders should not be used in conjunction with acid flux.

Silver solder (Type 1240-FPA) is available for applications where leadwire connections will be exposed to temperatures above about +550°F (*+290°C*). This solder, in paste form, is not suitable for attaching wires directly to strain gage solder tabs or to bondable terminals, but is intended for connecting instrument leads to preattached strain gage leads, as with WK-Series gages using a special resistance soldering unit. Techniques for making leadwire connections with silver solder are described in Micro-Measurements Tech Tip TT-602, *Silver Soldering Technique for Attachment of Leads to Strain Gages.*

Soldering Flux

The function of a soldering flux is to remove oxidation from the members being joined (solder tabs, terminals, leadwires), and to prevent further oxidation during soldering. For making leadwire splices, or soldering directly to constantan foil or copper terminals, the flux contained in a rosin-core solder is usually sufficient. With higher temperature solders, however, it may be necessary to supply additional flux. A liquid activated-rosin flux such as M-Flux AR is recommended for this purpose.

Acid fluxes should never be used on constantan strain gages or copper terminals, or for splicing copper leadwires; and paste fluxes, containing chlorides, should not be used under any circumstances for strain gage soldering.

When tinning bare (without soldering options) solder tabs of Micro-Measurements K- and D-alloy strain gages, a liquid acid flux (M-Flux SS) is recommended. After the tinning operation, the residual flux must be completely neutralized within one to two minutes; and then the leadwire joint can be completed using the same solder and M-Flux AR rosin flux or a rosin-cored solder.

Preparation of the Soldering Tip

New soldering tips should always be tinned with solder prior to initial use. This is easily accomplished by wrapping one to two in (*25 to 50 mm*) of solder wire around the working portion of the tip while the soldering iron is cold, before applying power to the soldering station. If rosin-core solder is used, no external flux is required. With solid-wire solder, however, the wrapped tip should be dipped into liquid rosin flux (M-Flux AR) to provide sufficient flux for initial tinning. Set the control on the soldering station to the appropriate temperature range for the solder, and apply power to the unit. Allow the soldering pencil to heat until the solder wrapped around the tip melts completely. Remove excess melted solder from the tip with a dry gauze sponge. Never knock the heated soldering pencil against any object to remove excess solder, since this may result in personal injury or damage to the soldering pencil.

Note: Cross-alloying of solders can change the electrical, chemical, thermal and mechanical properties of the solder being used. To prevent cross-alloying, it is recommended that only one type of solder be used with each soldering tip. Of course, if one type of solder is incorporated in a gage with solder dots and another type is added, a mixture is produced. This mixture cannot be expected to have melting and strength properties any better than those of the lower temperature component.

Oxidation of the soldering tip seriously hinders the soldering operation. The tendency for oxidation can be minimized by ensuring that excess melted solder remains on the tip at all times when it is not actually in use. Negligent maintenance practices, or wiping the hot tip with materials that char on the surface, will produce a buildup of oxide that prevents proper soldering. If the tip does become oxidized, the following procedure is effective for cleaning and re-tinning:

1. Set the soldering station to the appropriate temperature range for the solder in use.
2. Place several drops of M-Flux SS on a glass plate. Re-tin the soldering surface by holding the heated tip in the SS flux while feeding solder onto the tip. A generous amount of solder is essential for proper tinning.

Strain Gage Soldering Techniques

3. Wipe the excess solder from the tinned tip with a dry gauze sponge. For severely oxidized tips, it may be necessary to repeat this operation several times to obtain a properly tinned surface. The soldering tip should never be filed or sanded, since this may remove the plating on the tip, accelerating the oxidation and leading to the early deterioration of the tip. After the cleaning operation, remove excess solder, re-tin and clean the tip several times, using rosin-core solder, or solid-wire solder withM-Flux AR.

Tinning Solder Tabs and Bondable Terminals

All strain gage solder tabs, terminals, and leadwires must be properly tinned before making soldered connections. This helps ensure active surface wetting and good heat transfer during the soldering operation. Tinning stranded leadwires to produce a formable solid conductor will also greatly simplify the leadwire attachment procedure.

Before tinning the solder tabs on open-face (unencapsulated) strain gages, the measuring grid should be protected with PDT drafting tape. The drafting tape is positioned to cover the entire grid and the upper portion of the solder tabs, as shown in Figure 1. This not only shields the grid from soldering flux and inadvertent solder splash, but also restricts the flow of solder on the tabs. The tinned area on the solder tabs should be only large enough to easily accommodate the leadwire size in use. The latter consideration is particularly important when making installations for dynamic applications or large-strain measurement.

The tinning procedure for strain gage tabs and terminals consists of first cleaning and reapplying a small amount of solder to the hot soldering iron tip. Next, apply a drop of M-Flux AR to the tab or terminal (this step can be omitted if a rosin-core solder is used). When soldering directly to bare Karma or isoelastic foil, use M-Flux SS on the gage tabs only. Hold the soldering pencil in a nearly horizontal position (<30°), with the flat surface of the tip parallel to the solder tab or terminal. Place the solder wire flat on the gage tab, and press firmly with the tinned hot soldering tip for about one to two seconds, while adding approximately 1/8 in (*3 mm*) of fresh solder at the edge of the tip. This procedure assures that there is sufficient solder and flux for effective tinning. Simultaneously lift both the soldering pencil and solder wire from the tab area.

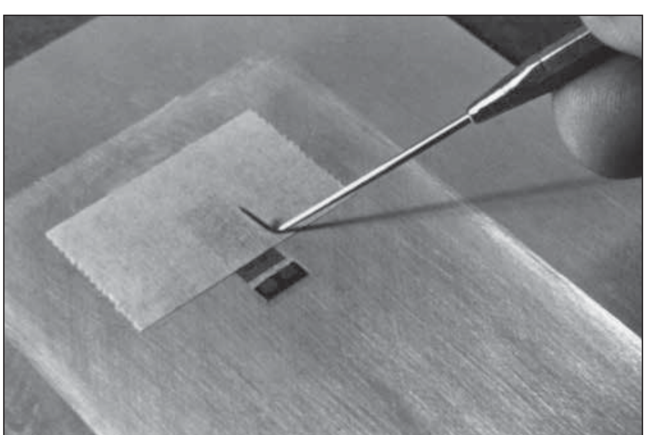


Figure 1 – Gage grid and upper portion of solder tabs masked with drafting tape.

NOTE: Lifting the soldering iron before lifting the solder may result in the end of the solder wire becoming attached to the tab; lifting them in the reverse order can leave a jagged (spike) solder deposit on the tab. When the operation is performed properly, it will produce a small, smoothly tinned area on the tab or terminal.

If M-Flux AR or a rosin-core solder is used in the tinning, it is not necessary to remove the residual soldering flux at this time. However, when M-Flux SS is employed to tin the bare solder tabs of K- or D-alloy gages, the acidic flux residue must be removed immediately following the tinning operation. To remove the residue, apply M-Prep Conditioner A liberally, and wash the area with a soft brush; then blot dry with a clean gauze sponge. Next, wash again with freely applied M-Prep Neutralizer 5A, and blot dry with a clean gauze sponge.

NOTE: Special procedures for tinning and wiring strain gages supplied with preattached solder dots are described in Micro-Measurements Tech Tip TT-606, *Soldering Techniques for Lead Attachment to Strain Gages with Solder Dots.*

Tinning and Attaching Leadwires

Of course, leadwire ends must be stripped of insulation before tinning, and this should be done with a thermal wire stripper to avoid the damage to the wire that often occurs when mechanical wire strippers are used. After the wires are stripped, the ends of stranded conductors should be twisted tightly together before tinning. The bare leadwire ends can then be tinned easily with the following procedure:

1. Remove excess solder from the soldering tip, using a dry gauze sponge. Then melt fresh solder on the hot tip to form a hemisphere of molten solder about twice the diameter of the wire to be tinned.
2. If rosin-core solder is used, slowly draw the bare wire through the molten solder while continuously adding fresh solder to the interface of the wire and soldering tip. With solid-wire solder, apply M-Flux AR to the

Strain Gage Soldering Techniques

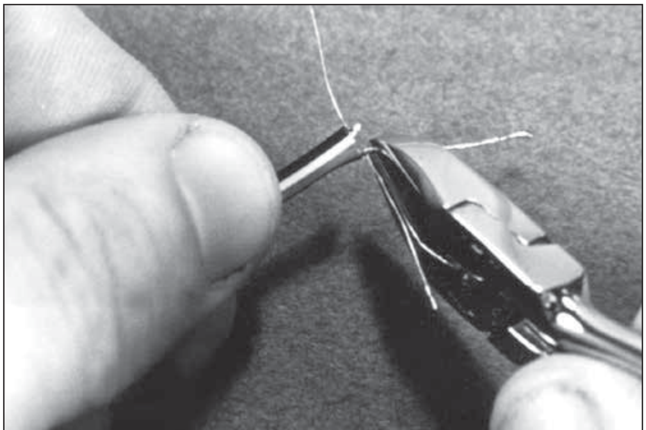


Figure 2 – Trimming leadwire ends before taping in place.

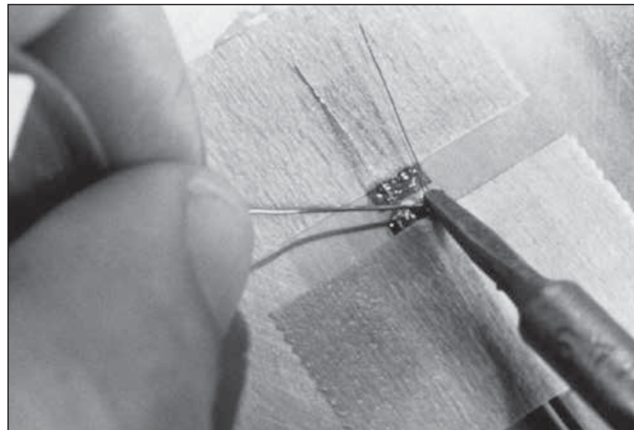


Figure 3 – Leadwire end taped to surface in preparation for soldering.

wire end before starting to tin, and proceed in the same manner. This will produce a smooth, shiny coating of solder over the bare wire.

For applications employing bondable terminal strips and stranded instrumentation wire, it may be convenient to use a single strand of the wire as a jumper between the terminal and the strain gage solder tab. In such cases, the single wire strand should be separated out before twisting and tinning the remaining strands (see Micro-Measurements Tech Tip TT-603, *The Proper Use of Bondable Terminals in Strain Gage Applications*).

Leadwires should be formed and routed to the strain gage or terminal strip, then firmly anchored to the test-part surface with drafting tape before making the soldered connection. Attempting to route the leadwires after completing the solder joint will often result in damage to the gage or terminals. Routing into the connection area should be along a minimum strain direction (such as the "Poisson" direction in a uniaxial stress field) particularly for high elongation or dynamic tests. The tinned leadwire end should be trimmed short enough so that it will not protrude through the connection area, and cannot inadvertently make electrical contact with the test-part surface or adjacent solder connections. Figure 2 illustrates this stage in the procedure. In the final preparatory step, bend the leadwire end slightly to form a spring-like loop, and tape the wire firmly in place over the connection area, using PDT drafting tape. The tape should be within about 1/8 in (*3 mm*) of the connection area, as shown in Figure 3.

Clean and re-tin the soldering iron tip with fresh solder. The temperature of the iron should be adjusted so that the solder is easily melted, without rapidly vaporizing the flux. If the iron temperature is either too low or too high, it may cause poor solder connections, or it may damage the strain gage, terminal, or bonding adhesive. Apply a small amount of M-Flux AR to the joint area and, holding the soldering pencil nearly horizontal, firmly press the flat surface of the tip on the junction for about one second; then lift the tip from the soldered joint. If needed, additional flux can be provided during the joining operation by feeding a little fresh solder into the joint from a spool of rosin-core solder. This procedure should result in a smooth, hemispherical solder joint, without any peaks or jagged areas. If the solder joints are not smooth and uniform in size, repeat the soldering procedure, using additional flux and/or solder as necessary.

Cleanup and Inspection of Soldered Joints

After completing the soldering operation, it is imperative that all traces of residual flux be completely removed with RSK Rosin Solvent. The same solvent is used to soften the mastic of the drafting tape, permitting its easy removal. Do not try to pull away the tape with tweezers or other tools, because this may result in damage to the soldered connections or the strain gage grid. Thoroughly clean the entire installation area with generously applied rosin solvent and a soft-bristled brush. Clean the solder connection area until no visible signs of residual flux remain, and blot the area dry with a clean gauze sponge. Any traces of residual flux can cause gage instability and drift, and will inhibit bonding of the installation's protective coating. Incompletely removed soldering flux is the most common cause of degraded performance in strain gage installations. Residual flux mixed with a protective coating application can completely destroy the coating objective.

Visually inspect the soldered joints for any gritty or jagged joint surfaces, and for traces of flux. Solder connections

should be smooth, shiny, and uniform in appearance. Any soldered joints that look questionable should be re-soldered, and flux removed. Check the resistance-to-ground of the completed gage installation, using the Model 1300 Gage Installation Tester. Low or marginal resistance readings suggest a leakage path between the soldered connections and the test-part surface. This condition usually results from residual soldering flux, or from bare leadwire conductors partially shorting the gage tabs or terminals to the test part. Soldered joints should not be tested by pulling on the leadwire, or by probing at the joint area. These practices frequently cause lifting or tearing of the solder tab from the gage backing material.

Summary

The ability to make consistently good soldered joints is essential for precision strain gage measurements. The techniques described here are straightforward and easily mastered, but they are most effective when used with professional soldering equipment which is specially designed for making soldered connections in strain gage circuits. The soldering pencil should be lightweight, with a flat chisel or screwdriver tip, and it should be connected to the soldering station with a very flexible power cord. Requirements for the soldering station include low-voltage operation of the soldering pencil, and provision for temperature adjustment to suit the type of solder and the application conditions. The equipment should not generate electrical interference that could affect sensitive measuring instrumentation. Solder selection is based primarily on the expected operating temperature range of the strain gage installation; and all solder tabs, bondable terminals, and leadwire ends should be tinned before soldering the joints. Soldered joints should always be smooth and shiny, with no jagged or irregular edges, and all traces of residual flux must be thoroughly removed prior to the application of protective coating. Use of the recommended materials and techniques, with careful attention to detail, will result in consistently proper and reliable soldered connections.

PROJECT LEAD THE WAY PLTW

Soldering & De-soldering

Digital Electronics

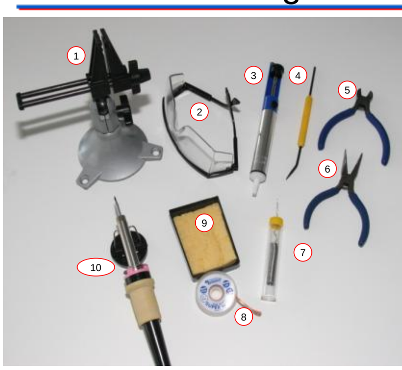
Soldering & De-soldering

This presentation will…

- Review the tools needed to solder and de-solder electronic components.
- Demonstrate how to *tin* a soldering iron tip.
- Demonstrate the soldering process.
- Show the characteristics of a good solder connection.
- Review classic soldering mistakes.
- Demonstrate the de-soldering process.

2

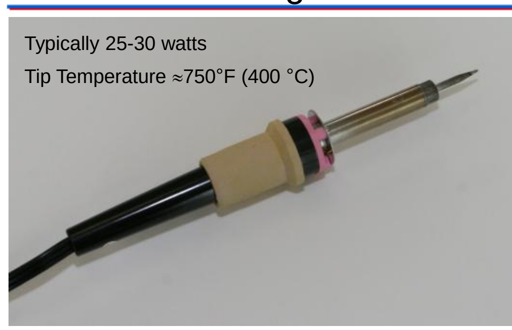
Soldering Tools



1) Vise
2) Safety glasses
3) Solder sucker
4) Solder tool
5) Diagonal cutters
6) Needle nose pliers
7) Solder
8) Solder wick
9) Damp sponge
10) Soldering iron

3

Soldering Iron



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Solder

- Solder is an alloy of tin and lead.
- The solder used for electronics is frequently called 60/40 solder because it is made of 63% tin and 37% lead.
- 60/40 solder melts at 361° F.
- Lead-free solder**:** As of July 1st, 2006, European laws mandated that new electronics be entirely lead-free. As of yet, no such laws exist in the United States.

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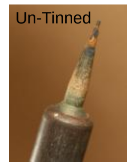
Soldering Iron Care & Maintenance



- A soldering iron must be coated with a thin coat of solder. This will allow for the transfer of heat to the work piece.
- This procedure is called tinning.
- The tip must be kept coated with a shiny layer of solder by occasional wiping and applying solder directly to the tip.

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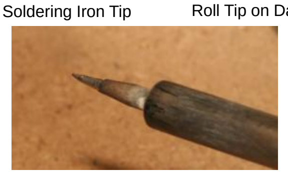
Tinning Process


Apply Solder to Soldering Iron Tip


Roll Tip on Damp Sponge

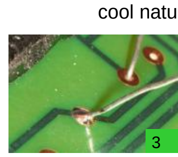

Properly Tinned Soldering Iron Tip

7

Solder Process

Heat both items at the same time by applying the soldering iron to the copper pad and the component lead.

Continue heating and apply a few millimeters of solder. Remove the iron and allow the solder joint to cool naturally.



It only takes a second or two to make the perfect joint, which should appear shiny.

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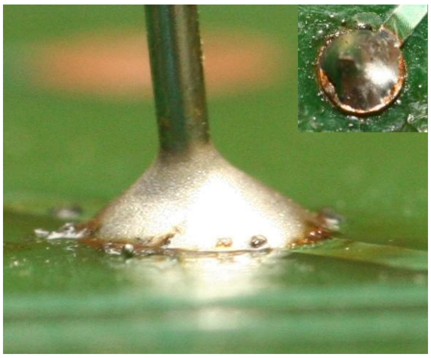
A Good Solder Joint



- Smooth
- Bright
- Shiny
- Clean
- Concave fillet

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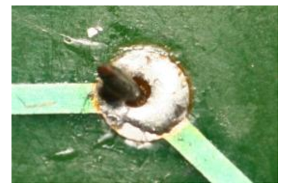
Bad Solder Connections

Too Much Solder

Too Little Solder



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Bad Solder Connections

Cold Solder Joint

Not Soldered

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Bad Solder Connections

Solder Bridge

Lifted Trace/Pad

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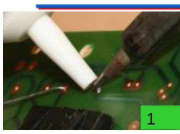
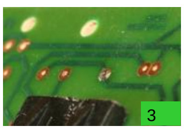
De-Solder Process: *Solder Sucker*



Apply heat to the connection to be de-soldered. When the solder melts, trigger the solder sucker.

Repeat de-soldering as needed until all solder is removed. Remove soldering iron & solder sucker from area.



Remove component lead.

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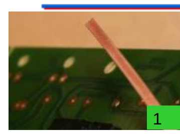
De-Solder Process: *Solder Wick*



Solder wick is finely braided copper that is used to *wick away* excess solder from a de-soldered connection.

Apply the solder wick and soldering iron to the de-soldered connection. The solder wick will draw the excess solder off of the PCB pad.

De-soldered PCB pad

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Soldering Safety

- Wear safety glasses when soldering. This includes all individuals in the vicinity of someone who is soldering.
- Place soldering iron in an approved holder when not in use. The iron is hot and can cause burns.
- Place the soldering iron so that the cord does not get caught up in your arms or on others.
- Ensure access to proper ventilation.
- Verify that the type of solder is safe to use in your working environment.
- Secure the components to be soldered before beginning the soldering process.

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Soldering Safety

- Provide plenty of space to work.
- Use a properly-sized point for the soldering job to be completed.
- Verify that the tip on the soldering iron has a sharp point and has not been damaged in any way.
- Check the power cord for burned or melted sections that show bare wires. Label those cords DO NOT USE and ask the instructor to repair or replace.
- Do not to touch molten solder - it is hot!
- Make sure that the solder strand is long enough to keep fingers away from the hot iron.

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Soldering Safety

- Tie back long hair and remove or tuck loose clothing.
- Use heat sinks for heat-sensitive parts. Provide sufficient cooling time before removing parts.
- Do not flick solder off of the iron. Flicking can cause solder to spray and hit skin or eyes.
- Hold the scrap end when cutting excess leads so that the scrap lead is not thrown into the air.
- Cut leads evenly with wire cutters.
- Make sure that leads do not short across other traces or leads.
- Thoroughly wash your hands after handling solder.

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How to Solder Like a Pro

Detailed instruction, helpful hints, safety tips, and a comprehensive troubleshooting guide

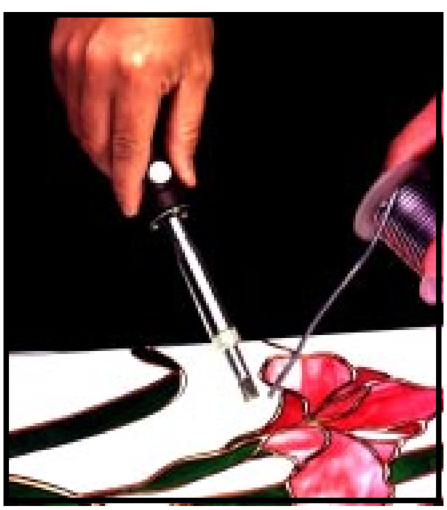

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Table of Contents

Thank you for your interest in Inland's <u>How to Solder Like a Pro</u> manual. Whether you are a beginner or an experienced stained glass artist, you will find useful information about selecting and maintaining your soldering tools and improving your soldering skills.

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Iron and Tip Maintenance

Solder

Flux

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Safety

The Importance of Safety

One of the most important aspect of soldering any stained glass project is to take the proper measures to safeguard your health. Soldering involves working with potentially hazardous materials like lead, flux and harmful fumes. By observing specific safety precautions and using informed common sense, working in stained glass can be a safe and enjoyable past time. The following is intended to serve as a general rule of thumb. Since each person and situation is unique, you should use this information as a starting point to help you make informed safety decisions concerning your soldering habits.

Fumes

Solder only in a well ventilated area, and use an exhaust device that moves solder fumes away from your face. It's preferable to exhaust outside (check local/state building codes and restrictions on venting to outside air). If you don't exhaust to the outside, use a bench top fan or intake device with a replaceable smoke/fume absorber made for stained glass artists. It should draw solder fumes into the replaceable filter. The filter should be activated charcoal and designed to remove particles smaller than 1/2 micron from the air. There are also several OSHA approved respirators available for fumes. Consider wearing one in conjunction with a venting system, especially if you plan on soldering for several hours every day.

Lead

Most popular solders used in stained glass are lead based. When you are using them, follow these precautions:

- Never eat, drink, or smoke in any area where soldering takes place.
- Always thoroughly wash your hands after soldering.
- Make sure your soldering equipment and supplies are kept out of the reach of children.
- Do not discard lead or solder scraps into the trash. Find a means or place to recycle them.
- Never use lead based solders or cames on items that will come in contact with food or children, or will be frequently handled. If you are making kaleidoscopes, jewelry or napkin holders, use lead free solder.
- Consider having your blood lead level checked by your physician on a regular basis to help you monitor your handling practices.
- If you are pregnant, or considering it, you should check with your doctor before using lead or solder.

Heat

Soldering tools operate at high temperatures, so these safeguards are important:

- Wear safety glasses! Solder and flux can "pop" and "spit."
- Solder on a fire resistant surface. Homosote, or dry wall are good .
- Never leave your iron plugged in and unattended.
- Do not overload a wall outlet with too many electric appliances.
- Never set your hot iron down on anything other than an iron stand.
- Replace the cord of your iron if it becomes worn or gets burnt.
- To prevent burning your fingers, use needle nose pliers or heat resistant gloves to hold small pieces.
- Never cut off a grounding prong on an iron plug to make it fit an ungrounded receptacle.

Soldering Irons

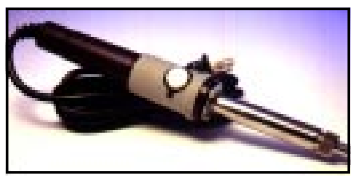
Choosing a Soldering Iron

There is a lot to consider when you choose an iron for stained glass. The handle should be heat resistant and comfortable for you to hold. You may be holding it for several hours at a time, so consider the weight and balance of the iron. Carefully check the wattage of the iron that you are considering. It must be able to continuously generate enough heat to melt all of the types of solder you plan to work with and be compatible with the type of construction you use (i.e.-copper, foil, lead came, rebar, etc.). You will need an iron that is at least 60 watts, with chisel type tips, and a way to control the temperature.

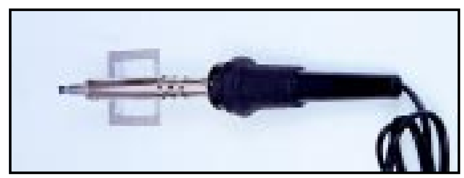
Types of Temperature Controls

A broad range of soldering irons are available. Most irons, which we will call "conventional irons," are made with wound wire heaters in a barrel with mica insulation. They are often inexpensive, but they do not offer the ability to control operating temperature. A separate temperature controlling device must be used with these irons to achieve the best results. There are three types of soldering irons that are easier to use for stained glass projects, because they allow you to control temperatures more effectively:

Irons with temperature controlled tips.



Irons used with temperature controlling devices.



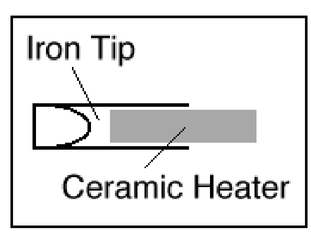
Irons with ceramic heaters.

Irons with Temperature Controlled Tips

These irons are supplied with an internal regulator in the tip that does not allow the iron to exceed a predetermined temperature. An example would be a 600°F tip. The iron heats to that temperature then "shuts off." When heat is required, the iron "turns on" again. Tips are available in predetermined temperatures up to 800°F. These irons are easy for beginners to use, because the temperature is automatically maintained for you, however, as your skills increase, you may prefer to control the amount of heat yourself for different soldering situations. The limited amount of control may become frustrating as your soldering skills increase. With this type of iron you will likely encounter "cold spots" where the iron will not melt your solder. These cold spots occur when heat is being drawn out of the tip faster than it is being replenished. You will need an iron with a minimum of 100 watts.

Ceramic Heating Element Irons

These irons are relatively new to the stained glass trade. They are made with highly efficient ceramic heating elements. Like a ceramic room heater, they produce a consistent temperature using less electrical wattage during operation. When initially heating and when reheating during "recovery" periods, they can draw a "burst" of power exceeding 100 watts and then efficiently reduce electrical consumption, often below 60 watts, during the soldering process. The result is efficiency and economy.



A remarkable feature of ceramic heater irons is they generally reach operating temperature in less than 60 seconds. Of the three types of noncoventional irons, the ceramic heater type best maintains consistent tip temperature over extended periods of time. Problems with slow heat recovery generally don't exist. A ceramic heater iron offers excellent flexibility and can be used with a temperature controller if you like.

Temperature Controlling Devices

A temperature controller is a device that operates similarly to a light dimmer switch. By dialing the control to a higher or lower setting, more or less electricity is fed to the iron. This increases or decreases the iron temperature, allowing the tip temperature to be controlled. You can establish the maximum temperature without changing tips.

A temperature control/iron combination offers you greater control and flexibility than a temperature controlled tip iron when working with different metals and solder mixes. Look for one that is at least 85 watts. Since the flow of electricity to the tip is consistent and never completely stops, encounters with cold spots are nearly eliminated. A temperature control/iron combination is suitable for all types of stained glass construction.

Temperature controllers are generally separate units that the iron plugs into. They are small, easy to use and relatively inexpensive. There are also irons that have controls built into the handle of the iron, which generally cost less than buying an iron and a separate control. Never plug an iron into a temperature control unless the manufacturer specifically states it is suitable for use with it.

Tip Sizes, Styles and Uses

Stained glass irons are generally sold with a "chisel" style tip. There are a variety of tip sizes and styles available for nearly every iron used in the stained glass industry. Different tips can expand the versatility of your soldering iron, so select an iron that offers more than one size replacement tip.

The standard tip size that comes with an iron is usually from 1/4" to 3/8" wide. This size works well for soldering either copper foil or lead came projects.

A smaller chisel tip, 3/16" wide, can be useful when soldering small pieces or when soldering in a tight area, such as a narrow inside part of a kaleidoscope. It is also very effective for decorative soldering.

Very small tips, 1/8" or narrower, are usually used for decorative soldering. They allow you to create very fine details and designs with the solder.

Iron and Tip Maintenance

The Importance of Proper Care

Your soldering iron may very well be one of your biggest tool investments, so you will want to do everything possible to ensure that it gives you many years of service. Well maintained soldering irons and tips perform better and make the job of soldering much easier. Always place your soldering iron in a stable iron stand whether it is being used or not.

The Cord

- Make sure you plug the iron into the correct type of outlet.
- Try not to use an extension cord. If you must, use a heavy duty one.
- Don't drop or bang the iron. Ceramic heaters are especially easy to crack or break.
- Regularly check the cord for burns or cracks and have a professional electrician replace worn cords before using the iron.
- Make sure that the cord is not hanging in such a way that it can be pulled off of the table.

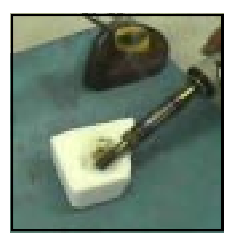
The Heating Element

- Do not allow the iron to idle at operating temperatures for extended periods. This could burn out the heater element. Unplug the iron or, if you are using a rheostat, turn it down to a low "idle" setting.
- Occasionally, remove the tip and **lightly** tap the barrel of wire wound heater irons to remove debris.
- If you will not be using your iron for an extended period of time, you may want to store it (after it has fully cooled) in a zipper type bag to protect it from corrosion and humidity.

The Tips

- When you are finished using your iron, remove the tip from the barrel. Removing the tip is essential to preventing "seizing" which can occur if it is left in the iron for extended periods. (If your tip seizes, you can easily damage the heating element trying to remove it. It is best to return you iron to the manufacturer for removal.)
- When reinserting tips, make sure they are properly seated in the barrel.

- Never dip your tip into flux in order to clean it. Instead, use a clean damp sponge to wipe all sides of the tip periodically as you solder. Doing this removes impurities the tip has accumulated from the solder and the environment. It will ensure that you are receiving the maximum heat at the tip surface.
- Properly cleaned tips are bright and shiny. If your tip becomes "blackened," you can usually remove the buildup with a wet sponge, a tinning block or by gently using a brass brush. A “tinning block” (sal-amoniac) is used by placing a small amount of flux on the block and rubbing the tip of your hot iron in it. Wipe the tip on a damp sponge to remove debris. You may need to repeat this several times if your tip is very dirty.)



- Never use sandpaper or any abrasive material to clean a tip.
- The best way to minimize your tip maintenance is to find a good quality solder. Use one that has a high tin content and high metal purity.

Solder

Why Do We Use Solder?

Solder is a combination of tin and lead used to create a strong bond between other metals. Since solder won't stick to glass, we apply a copper foil tape (our metal) to the edges of the glass. This is refered to as the copper foil method of stained glass construction. Solder is melted over the copper foil, creating a structure that holds the pieces of glass together. The other option is to set the glass into channels of lead or metal, and solder the channels together. This is refered to as the lead came method.

The Advantages of Solder

Some of the advantages of soldering versus other bonding methods are:

- Solders are easy to use and relatively inexpensive.
- Low energy is required to solder.
- Properly soldered joints are highly reliable.
- Solder joints are easy to rework or repair.
- Experienced craftpersons can exercise a high degree of control over the soldering process.
- Solder joints age very well. They can last for years, decades and centuries.

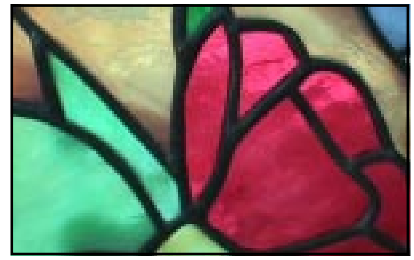
Types of Solder

Stained glass solders are usually a mixture of tin and lead, designated by two numbers representing the percentages of each metal in that specific mix. The first number always refers to the percentage of tin, the second is the percentage of lead. The most commonly used solders in stained glass are 60/40, (60% tin/40% lead) 50/50 and 63/37. "Lead-free" solders have no number designation and are a mixture of tin and small amounts of other metals. Avoid solders containing antimony, a very toxic element. Instead look for lead-free solders containing silver, or copper. They are safer and easy to use. (Note they are, however, more difficult to patina.)

In North America, you will find solder is generally sold in solid core wire form on a spool. The common spool size is one pound. In Europe, you will find solders primarily sold in a bar form. Never use acid-core or rosin-core solders for stained glass work. Look for solders that are sold as "free of impurities" in the component metals. Impurities cause a "scum" on your solder bead, degrade soldering iron tips, and interfere with the proper reaction of patina chemicals resulting in undesired finishes.

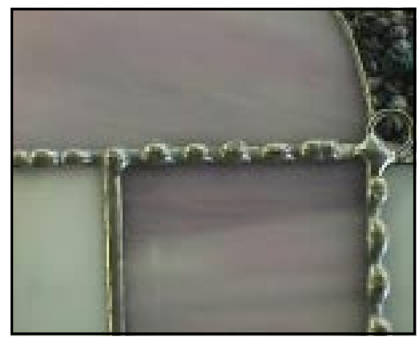
An important term for solders is the "working range" or "pasty range." This is the range of temperature between which solder transitions from liquid back to solid.

Characteristics of Solder Types

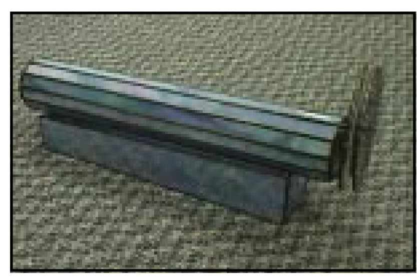


60/40 Solder: Composed of 60% tin and 40% lead, this solder melts at 374^{o}F, but doesn't become completely solid until it cools to 361^{o}F. This means it has a "pasty range" or "working range" of 13 degrees. This solder is your best choice for copper foil work. The liquid temperature and narrow "pasty range" make it easy to form and maintain consistent high, rounded, beaded seams. Because of its relatively low melting point, "60/40" solder is easy to rework to maintain a smooth finish solder bead.

50/50 Solder: This is composed of 50% tin and 50% lead. It is liquid at 421^{o}F, solid at 361^{o}F and has a pasty range of 60 degrees. This solder will produce a much "flatter" bead than 60/40. Because of its higher melting point, 50/50 solder is often used on the back (or inside) of a stained glass project to protect against "melt through" when soldering the front. Because it spreads and flattens out, 50/50 solder is often used when soldering lead came joints.



63/37 Solder: This solder is 63% tin and 37% lead. It becomes liquid at 361^{o}F, and solid at 361^{o}F, with a pasty or working range of 0 degrees. This solder is called a eutectic alloy which means at 361^{o}F, you can go instantly from solid to liquid to solid just by applying or removing the heat source. You will often find "63/37" solder referred to as decorative or quick set solder. It is primarily used to create dimensional effects in the solder itself and can be "pulled" and manipulated to produce a variety of textures and designs. 63/37 solder also makes an excellent solder to bead up the outside rim of copper foiled pieces.



Lead-Free Solder: Depending on the specific mix of metals, lead free will produce differing liquid, solid, and pasty range temperatures. Check with the solder manufacturers for these specifics. Lead-free solders will perform similar to a 50/50 mix. Lead-free solders require more practice in order to obtain a smooth bead on copper foiled pieces and should not be used on lead came projects. Lead-free solder is the most expensive solder, but is the solder of choice when constructing pieces that will contact food, that will be handled frequently, or that will be used in a child's play area or room.

Solder Composition Reference Table

Alloy	Tin%	Lead%	Solid to	Liquid at	Pasty Range
50/50	50	50	361^{0}	421^{0}	60^{0}
60/40	60	40	361^{0}	374^{0}	13^{0}
63/37	63	37	361^{0}	361^{0}	0^{0}

Flux

Why Do We Use Flux?

Flux is a chemical compound that is used to promote the bonding of metals by removing the oxide residue simultaneously with the soldering process. Most metals left exposed to the air around us react with the air to form residue on the surface of the metal. The process is oxidization and the residues are oxides. Each mix of metals being joined has a specific flux that best promotes this bonding process. In stained glass, the metals being joined are primarily copper to tin/lead solder and lead, brass or zinc to tin/lead solder.

Types of Flux

Selecting the correct flux for your application is as critical as any other step of the soldering process. The proper flux will assure less soldering problems and a satisfactory solder bond. The best fluxes do three things:

- They remove all the residue that has formed on the surface of the metals you are going to solder.
- They prevent oxides from forming while you are soldering.
- Any post-soldering residue they leave is noncorrosive and easily cleaned off.

Fluxes are available in organic and inorganic forms. If you touch the flux and your skin seems to have a sensitivity to one type of flux, an inorganic type for example, try an organic variety. Often you will find that you are less sensitive to irritation by using the opposite type flux. Organic fluxes are generally some form of oleic (fatty) acids, while inorganic fluxes are most often zinc chloride based.

Characteristics of Fluxes

Liquid flux is the most widely used. It may or may not be water soluble. Water soluble fluxes clean up very easily, but are thinner and some have a tendency to evaporate quickly and require repeat applications. Some liquid fluxes are thinner than others and have a tendency to run or spread out from their point of application.

Gel Flux is generally water soluble and "adheres" well to the surface being soldered. Gels tend not to evaporate as readily as liquid flux, but if you apply too much, they produce more "spitting" and "popping" as you solder.

Paste Flux is very thick, stays where it's applied, and doesn't evaporate easily. It's effective when soldering 3-D forms such as lamps. Paste fluxes can be difficult to clean. Be very careful not to over apply a paste flux as it will also spit and pop, leaving pits on your solder seams.

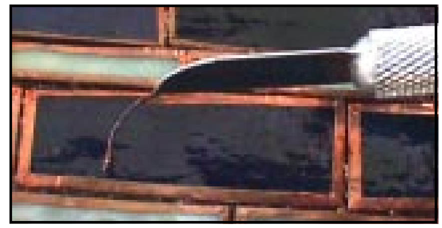
Getting the Most From Your Flux

It is important to keep your flux clean and free of impurities. This will ensure the purest possible solder joint. One way to keep your flux clean is to avoid dipping in and out of the original container. Pour out the amount you will need for your current project into a separate, smaller container. Don't leave the flux bottle sitting around with the cover off. Never pour leftover flux back into the original container. Fluxes often will produce fumes as you solder. Make sure you are aware of and follow the precautions suggested in the health and safety section of this guide.

Soldering Basics for Copper Foil

The quality of the solder job can make or break your project, yet it is the step that takes the most practice to become good at. Soldering is more difficult than the other steps in stained glass because there are so many things that can effect it: the amount of heat, the amount of solder, the type of flux, the rate at which you move, gaps in the project, etc. The following step-by-step instructions will give you the basics of soldering. If you are just starting out, you will learn a lot. If you are experienced, you may just find the trick that makes it all come together. Great soldering takes a little bit of knowledge and a lot of practice.

Before You Start

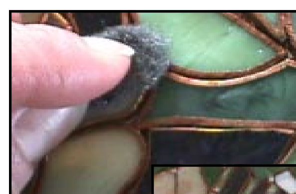


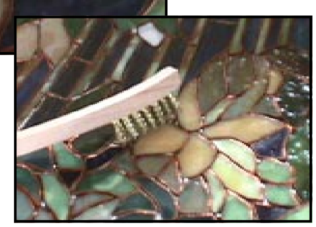
Preparation is the key to producing a good solder bead. Here are some suggestions to help you get of to a great start!

- Make sure that the foil is seated properly over the glass.
- Trim all overlaps in the foil using a sharp craft blade.
- Assemble all the tools you will need so they are at hand.
- Wear safety glasses.
- Have a proper ventilation set up.
- Make sure the foil is well burnished and sealed smoothly to the glass surface.
- Secure the glass pieces using pins, or squaring blocks made for this purpose before soldering.

Set aside enough time to solder your entire project all at once. If you don't, dried flux and solder residues on the unfinished parts will make further soldering difficult. Flux allowed to remain on a project can compromise the strength of the solder joints.

Cleaning Before Soldering





Sometimes the surface you are going to solder needs cleaning to remove visible grime, dirt, residue or oxidization. In this case, use 000 or 0000 steel wool to clean the surface of copper foil. For lead came or excessive oxidation carefully use a soft brass brush. If you won’t be able to solder your project immediately after it is copper foiled, store it in a plastic bag to help reduce oxidation. If you partially solder the project and have to stop before it is complete, be sure to clean off all of the flux and store the project in a plastic bag until you are ready to continue. You will probably still need to use steel wool on the joints when you are ready to solder, but the clean up should be minor.

Getting Started

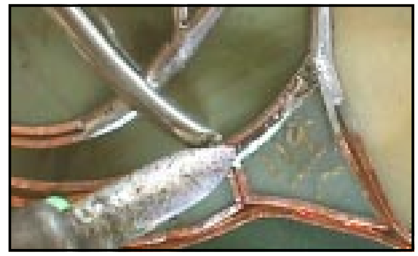
Begin the soldering process by fluxing all intersections of the glass project. Then "flat tack" solder these intersections together by using a very small amount of solder and the flat face of the iron tip. The solder should lay flat on the intersection and you shouldn't have any beads or bumps of solder on the piece. Hence the name "flat-tack" soldering.

Now, fill any gaps between the glass pieces by melting solder into them until the solder is level with the surface of the glass. If you have large gaps, you can ball up some copper foil, with the sticky sides together, and fill the gaps. This will help keep the solder from seeping out the other side.

"Tin" the entire perimeter making sure to work some solder into seams that intersect the perimeter. (Tinning is the process of coating a surface with a thin layer of solder. Apply just enough solder to turn the foil to the silver color of the solder.) This creates a "dam" that prevents solder from spilling over the edge when you solder the interior seams.

Next, flux an area you can comfortably finish soldering before the flux can evaporate. Start at the top of the piece and work down. This prevents you from dragging your sleeves and hands through the flux.

Running The Solder Bead



Hold your soldering iron in your writing hand. Position the iron comfortably so the face of the iron tip is perpendicular to the seam. If you hold your iron like a carving knife you will automatically put the tip in the best position for soldering. It will also keep you from "painting" with the iron. You will hold the solder in the opposite hand. Start soldering by placing the iron tip down on the foil seam with the wider face perpendicular to the seam and facing you. Touch the solder to the tip of the iron, just above the point where the iron tip touches the copper foil. Allow the solder to flow down the tip face onto the seam as you move the iron along the seam. Feed the solder at a continuous, even rate to create a consistent, rounded bead of solder over the seam. This takes practice!

If you apply too little solder or move too quickly, your seam will be flat. To correct this problem, allow the solder to cool, then resolder the joint applying more solder. On the other hand, be careful not to feed the solder too fast or move the iron too slowly, as this will cause the solder seam to bulge and flow out over the glass.

Fixing Imperfections

If you have too little solder, just add more, being sure to remelt the previous solder line as you apply another coat. If you applied too much solder the first time, it's easy to remove the excess with the following procedure. Clean your iron tip thoroughly on a sponge. With the iron tip positioned with the flat face down, move it across the seam, "pulling" the excess solder onto the glass. Clean your tip and repeat the process until all excess solder is removed. Another method for removing excess solder is to wait until all the seams have been soldered. Then place your project up on edge and run the tip through the seam allowing the excess to run off. Lay the piece flat, reflux, and rework the seam, adding additional solder as needed.

When you solder, work slowly enough to produce a good bead, but not so slowly that solder melts through seams to the back side of the project. Here's a hint: one way to prevent this is to put damp paper towel under your panel before you start soldering. Moving too slow also increases the likelihood of causing heat fractures on your glass.

Other Things To Consider

Always keep your tip clean by frequently wiping all sides of the tip on your damp sponge. Wait momentarily for the tip to reheat before continuing to solder. A clean tip maintains proper heat and removes impurities.

To achieve a smooth solder line, solder the longest continuous seam possible. Don't start or stop a solder seam at an intersection with another seam. As you meet an intersection, allow the solder to break or "y" out over the intersecting seam about 1/2" and then return to the original path you were soldering in one continuous motion. As you continue to solder seams, you will connect these branches, thus preventing pulling out at intersections of seams (which is a noticeable sign of a beginner). When you encounter a "v" type joint. Solder in a direction that moves up into the "v" point, instead of coming down onto the point. This keeps a nice clean "v" joint without excess solder obscuring it. Do this by soldering up one leg of the "v" and as you approach the apex, drop your iron tip down flatter on the glass, so that it crosses over both seams. Then continue soldering into and out of the point of the "v."

Avoid a "painting" motion when soldering. Visualize your iron as a magnet pulling along a metal strip. Maintain a small puddle of solder at the base of the tip as you solder. When two adjacent pieces of glass vary in thickness, ride the tip on the higher piece of glass as you solder.

Effects of using the iron like a paint brush

A big advantage of using copper foil is that not-so-perfect solder seams can be reworked. Allow the seam to cool, reflux it, then resolder. Be careful because reworking a seam too many times (more than 2-3) can cause the adhesive on the foil to loosen and bubble.

Solder one side of your project completely, then turn it over and repeat the process on the other side. Some of the flux from the first side you soldered will have seeped to the other side. You may encounter more "spitting," so use flux very sparingly. To achieve a smooth, beaded solder seam: practice! practice!

Ending A Bead

When you are ready to end your seam, pull off across the face of the glass making sure you are in a liquid section of the solder seam and do not lift straight up. This technique leaves a smooth exit point that is virtually unnoticeable. You may notice that this is the same photo used for removing extra solder. It’s not a mistake. The action is very much the same.

Practice!

Creating perfect solder seams takes practice. One good way is to make a practice board. Make sure to include all types of intersections and lines (curvy and straight). Foil the piece and flat solder it on the front and back. Practice each different soldering technique. When you are finished, you can hold the piece vertical and melt the solder off. Now you are ready to start again. Many people use the practice board before they start soldering each project, just to get the feel of soldering again.

Cleanup After Soldering

After soldering, you will need to remove all flux and solder residues from your solder lines and glass. The best cleaners to use are ones that neutralize the acid property of fluxes. To properly clean your project, you will need a good flux cleaner, very warm water and a soft scrub brush. Thoroughly brush the cleaner into every corner of your project, front and back. Follow this with a long rinse in clean, warm water and then towel the project dry. This step is very important because any flux that remains will continue to react with the solder, causing oxidation. If your project looks good after the initial cleaning, but the solder lines have a white or green growth on them after a few weeks, it generally means that all of the flux was not removed from the project. You can use 000 steel wool to remove the patina and finishing compound and thoroughly clean the project. Then reapply the patina and finishing compound.

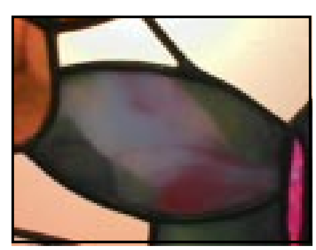
A small stiff scrub brush is the best way to clean the entire project. After the initial cleaning, you may find some areas that need additional attention.

You may find small pieces of solder stuck to the glass. You can easily remove these using your fingernail, or 000 steel wool. Be careful not to scratch the glass.

An old toothbrush can be helpful for cleaning in tight intersections and right up against the solder line.

Occasionally you may find that after applying patina, certain types of glass acquire a “rainbow” effect. This is most likely to occur on hot colors, black, white and iridized glass. It is one of those things that is unpredictable and difficult or impossible to remove. You can try to remove it by using a paste made from baking soda, but it doesn’t always work. The only way to prevent this occasional problem is to be very careful not to get patina on your glass. Use a cotton swab to apply the patina only to the solder lines of the project. If you have this problem, it is a good idea to make note of it on any remaining glass, so you can be more careful the next time you use that particular glass.

Finishing

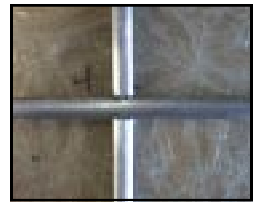


After cleaning your project you should use a finishing wax or compound to keep it looking it’s best. A good quality carnauba wax or pre-mixed wax and cleaner should be applied to all of the solder lines. A nice side effect is that the wax also enhances the color of the patina making it either rich black or shinny copper. You may find it helpful to reapply the wax after a few months. (If you would like to change the color of the solder, see the section about patina on page 16.)

Soldering Basics for Metal Cames

Lead came construction requires a different soldering technique than that used for copper foil. You can use the same iron and flux, but the preparation and actual soldering will differ. You will be soldering only the joints, instead of running an entire bead. With a little knowledge and some practice, you will be able to make perfect solder joints on lead or other metals.

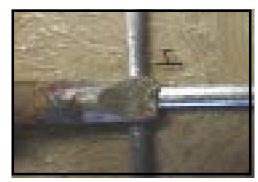
Getting Started



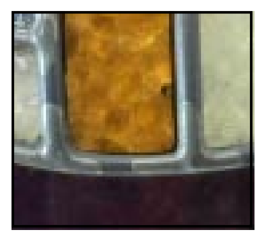
First, make sure that all joints are in line with each other and butt against each other with no gaps. Use a triangle and/or square to check the squareness of the panel and make sure that your lines run true across the panel in all directions. Make any adjustments that are needed. Thoroughly clean surface oxidation from intersections with a soft brass brush.

Soldering

The most desirable solder to use when constructing a lead project is 50/50. It flows out from the point of contact, leaving a nice joint. Do a "lead" test to check the heat of your iron. Allow the iron tip to heat for several minutes. Then, place the flat face of the tip on a scrap of lead. If the lead melts, the iron is too hot. Lower the temperature or change to a lower temperature tip. (This is where a rheostat iron is great.) Now test the tip with 50/50 solder to make sure it can melt it. If it does, your tip temperature is adjusted correctly. If not, raise tip temperature just until you melt the solder. Recheck the tip temperature and test it on the lead again. Now flux all the joints on your panel.



Begin by holding the solder on the joint. Move in to the joint across the glass, not from across the came. The wide face of the tip should be down toward the joint. Coming into the joint over the glass prevents leaving a solder trail on the lead came at one end of the solder joint. Techniques like these are the signature of an accomplished craftsperson.



Melt only a small amount of solder and move the tip in a slight circular motion allowing it to flow out over the joint a distance equal to the width of the came being used. Pull the iron tip straight up off the center of the joint. The desired end result is that intersections of the lead cames are not visible through the solder and the solder on them is smooth, not beaded. You should be able to run a fingernail over the came and into the soldered joint without it catching or clicking. Solder the joints on the front of the project. Then turn the project over and repeat the same process on the back.

Finishing

Lead projects need to be finished by applying a cement. The cement will weatherproof the project and secure the glass in the channels. This step is necessary on any came project to ensure a strong, secure panel. Cement is easily applied to the panel by using a small scrub brush to work the cement under the channels both on the front and back of the project. After the cementing process is complete, whiting sprinkled over the entire surface and allowed to absorb excess moisture for a few minutes. Using a stiff brush, vigerously brush the lead channels, removing excess cement from the glass. The brushing process allows a natural patina to form on the lead, so it is not necessary to apply patina to the project. Allow the project to dry thoroughly, usually for a few days, before installing or hanging the project.

Soldering Basics for Other Metals

Vase Caps

Vase caps are generally made from spun brass. The cap must be very clean of all dirt and oils for the solder to adhere. Use 0000 steel wool to clean the areas that you will be soldering. The cap also needs to be quite hot in order to achieve a good bond between the solder and the brass. An easy way to get the cap hot is to heat it in a hot oven for about 15 minutes. Use pliers to carefully remove the cap from the oven. Center the vase cap on the lamp. Flux all areas you will be soldering. (Paste flux is easy to use for this purpose, because it doesn't drip.) Get a small amount of solder on your iron and hold it on the vase cap for a minute or so at the area you want to make a connection to the lamp. When the cap is hot enough, the solder will spread out instead of lumping up. Add more solder to make a connection to the lamp. (Some vase caps have a lacquer finish on them. This must be removed at the areas you need to solder. Use a craft knife to gently scrape the lacquer in these areas.

Spiders

Spiders are made from brass as well. You can either cut the legs to fit, or bend them. Like a vase cap, you need to get the brass quite hot in order to create a good bond with the solder. Unlike vase caps, you can get the smaller area of the spider hot enough using just your soldering iron. Simply hold your iron tip on the area that you need to solder for a minute or so. Apply flux and a little solder, and continue to heat the spider with your iron. When it is hot enough, the solder will smooth out around the spider leg and adhere to the lamp. If the solder is globed up, the spider leg isn't hot enough. Continue in this manner for all of the legs.

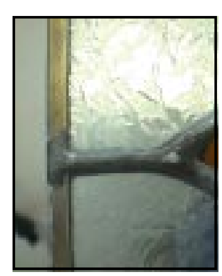
Metal Outer Channels

When attaching a zinc, copper or brass edge to a project, use this solder technique: Cut the zinc, copper or brass came vertical members to overlap the horizontal members in a "butt" type joint. A butt joint provides structural stability and distributes weight. Before you solder the butt joints, you can use masking tape to contain the size of the solder joint.

Clean and flux these joints and solder them to each other using the flat tip of the iron on the metal. The metal channel will take a little longer to get hot than copper foil. If the metal is not hot enough the solder will not smooth out. The metal frame should be attached to the panel by soldering it to any lead lines that it touches.

On leaded projects, solder from the outer metal edging onto the lead came, pulling the iron tip straight up over the point of intersection when completing the solder joint. This simple technique will level the solder smoothly over the joint.

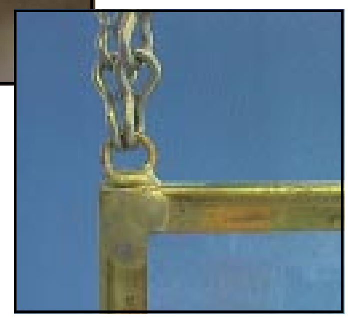
For copper foil pieces, stop your solder bead about 1/4-1/2" from the outer edge to allow room for the metal edging to fit onto the perimeter of the project. If you forget to do this initially, flatten the solder bead so the outer edging fits onto the project. After fitting the outer edging material, flux and solder the corners as outlined above. Connect the copper foil beads that intersect with the outer edging metal by continuing the solder bead into the edging making sure that the



solder adheres securely to the metal edge.

As you work more with your iron, different solders, lead came, and copper foiled projects, your skills will increase. You will quickly develop the techniques that will make you more confident in tackling increasingly complex projects.

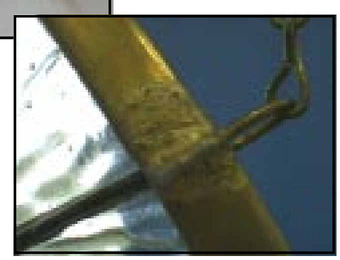
Hanging Hardware



There are many ways to hang your project. You will want to make sure that the method you choose will support the weight of the project. You can purchase pre-made hardware from your stained glass store, or make your own using any type of solderable wire. If you are using wire look for 16 to 18 gauge.

Rings can be added to the metal border of the project if it is not too heavy. A general rule of thumb is about one square foot. Hold the ring with pliers and solder rings to the metal border of the piece wherever they allow it to hang properly. Just like soldering the channel together, if you don't allow the metal to get hot enough, the solder will not adhere well. This will result in your hanging rings failing.

A stronger type of hardware is made using wire. Twist together four strands of 16 -18 gauge wire, leaving a loop at the end. Cut the wire to about 1/2". Insert the wire into the opening of the metal channel, bending the loop the direction you need it to be. Solder the hanger to the channel and fill the opening with solder.



Another option is to make a loop from twisted wire and solder it to the front and back of the metal channel, with the loop extending above the project. Be sure to solder the hanger into an existing solder joint, not just to the channel. This will prevent the weight of the project from pulling the channel away from the glass.

By the way, the joint on the hanger at the right was painted to match the brass channel using a gold paint pen.

Patina

Solder and lead change color naturally over time, but you can change their color instantly by using patinas. There are several different formulas producing a variety of colors. Patinas are easy to use. Make sure that your project is thoroughly clean and free of solder, flux and cutting residues. Use a brush or soft rag to apply the patina to the solder until you reach the desired color. Wash the panel again to remove any patina from the glass.

- 👍 When using antique brass patina, first scrub your solder seams with fine steel wool. Apply the patina sparingly with a clean brush, using only a few strokes. Over use will produce a coppery finish.
- 👎 Never mix patinas and always use proper ventilation and skin protection.
- 👍 To get a nice black finish on brass, add a dash of table salt to a little black patina in a glass or plastic jar. Mix well, apply and allow to dry. Clean and finish a usual.

Trouble Shooting

Problem: The solder won't adhere to the foil or came.

Solutions/Explanations:

1) Did you apply any flux?
2) Did you apply enough flux?
3) Was your iron too cool?
4) Is the foil or lead came too oxidized for flux to activate the surface?
    A) Buff copper foil with 000 or 0000 steel wool.
    B) Clean lead came with brass brush.

Problem: Solder is melting through to the backside of my project.

Solutions/Explanations:

1) Your iron is too hot. Depending on what type of iron you are using, either turn the temperature controller down or change to a lower temperature tip.
2) You may be soldering too long in each area. Move on and let the solder cool. Return to those spots later.
3) The gaps between your glass are too wide. Try to fill the gaps with solder and let it cool. Then go back and solder a bead on top of the filled gaps.
4) Try placing a wet paper towel under the project to provide cooling.

Problem: My solder is "stiff." I am unable to get a smooth bead.

Solutions/Explanations:

1) Your iron is too cool. Depending on what type of iron you are using, either turn the temperature controller up or change to a higher temperature tip.
2) You may not be using enough flux.
3) Is the tip of the iron getting hot? Check to see that the tip is seated correctly down in the barrel of the iron.
4) Are you "painting" with solder, instead of running a long bead with a steady, even, one directional movement? This is one of the most common mistakes that beginners make. In order for the solder to create a bead, it has to get molten. If you are using the iron as a “paint brush”, the solder is not getting hot enough to melt thoroughly.
5) You may be soldering with just a corner of the iron tip. Check for proper positioning of your iron.
6) Try a different solder with a lower melting point.

Problem: My iron seems to be hot, but the solder isn't melting as fast as normal.

Solutions/Explanations:

1) Check your tip. Is it loose?
2) Is your tip too dirty?
    A) Clean it on a wet sponge.
    B) Clean it on a tinning block.
3) Your tip is too corroded or defective. Replace it.
4) Your rheostat may be malfunctioning.
    A) Plug the iron into the outlet you are using without the temperature controller. If the iron works, the controller is malfunctioning. If the iron doesn’t work, the problem may be with the iron itself.
    B) With some types you can check the temperature controller by plugging a lamp into it. Turn on the lamp and see if the controller dims and brightens the lamp.

Problem: My solder seams are flat.

Solutions/Explanations:

1) You are not using enough solder. Reflux your project and add more solder.
2) You are soldering too fast. Move at a speed that lets the solder bead.
3) If the bead was there, but disappeared, you may be working too long in one area causing the solder to melt through to the other side. Allow the area to cool down before trying again. Another option is to place a damp paper towel under the seam you are working on. This will help keep the glass cool, allowing you a little more time to work.
4) Check the type of solder mix you are using. For copper foil work, 60/40 will help produce a higher, more rounded bead. Don't make the mistake of buying 40/60 solder. It has an even longer pasty range than 50/50, and is not recommended for stained glass work.

Problem: My solder seam is too wide.

Solutions/Explanations:

1) Do you have large gaps between the pieces you are soldering?
   A) You may have to recut some pieces.
2) You may be using too much solder causing the seam to bulge over onto the glass. "Pull" or "bleed" the excess solder from the seam.
3) Is the copper foil too wide? This is another common mistake for beginners. Remember that the width of the solder seam is determined by the width of the foil. An attractive solder seam is accomplished by using a foil that shows about 1/16" on both sides of the glass.

Problem: My solder seams are irregular in width.

Solutions/Explanations:

1) You may have poorly fitting pieces that create different size gaps in your project. Recut these pieces.
2) Your foil may be applied unevenly on each side of the glass in some places. You may try to correct this by trimming the foil with a craft knife. If that does not work, remove the foil and start again.

Problem: My glass fractured while I was soldering.

Solutions/Explanations:

1) Your iron is too hot. Depending on what type of iron you are using, either turn the rheostat down or change to a lower temperature tip.
2) You "worked" too long in one location with the iron.
3) There could have been a small chip or crack in the glass which was expanded when it was heated by the iron.

Problem: My solder bead is not bright and shiny. It appears dull and splotchy.

Solutions/Explanations:

1) The solder was applied too cold, so it never fully reached its "liquid state." Turn up the temperature if you are using a rheostat or change to a higher temperature tip if you are using a temperature controlled tip.
2) You may not be using enough flux to "wet" your foil or lead and create a proper solder condition.
3) If you're using 50/50 solder, try 60/40. Because solder crystallizes as it cools through the pasty range, 50/50 is more prone to having a textured look on its surface because of its considerably larger pasty range.
4) The solder you are using may be of inferior quality.

Problem: My solder is "spitting" as I work. What's wrong?

Solutions/Explanations:

1) You are likely using too much flux. It is literally boiling when you apply the solder. Wipe some of the flux off with a paper towel and try soldering again. You may find areas that now need a little more flux, because you removed too much.
2) If the spitting only occurs on the back side of your project (or the second side you are soldering), the problem is still too much flux, but the cure is different. When you use too much flux on the front side of the project, the excess to flows through the panel, so the spitting isn't as bad as it could be. When you use too much flux on the back side of the project, it can't flow through to the front, because the front is already sealed. The obvious cure for this problem is to use less flux the next time. But what about now, when you already have too much and can't remove it from between the glass? The only good solution is to apply your solder, and allow the flux to boil up and out of the seam. (Keep your face as far away from the project as you can.) Once it stops spitting, you can remelt the solder and make it look as good as new.

Problem: I have gooey, glue residue along my solder seams that won't wash away.

Solutions/Explanations:

1) Adhesive from foil may be working up and out onto your glass. This can be caused by poor foiling or burnishing of the copper foil, which allowed flux to seep underneath the foil. To correct this use a cuticle stick or soft toothbrush to clean adhesive away.
2) Your iron is too hot, causing the adhesive on the back of the foil to melt and seep out onto the glass. Depending on what type of iron you are using, either turn the rheostat down or change to a lower temperature tip.
3) If you reworked a seam too often, it may have loosened the foil. Allow the seam to cool to the touch and gently press the foil back down to the glass.

Problem: Attached hooks and rings are pulling away from my project.

Solution/Explanations:

1) Hooks and rings should never be attached to just a foiled edge. Attach hooks/rings to vertical seams in the piece or at a juncture between a vertical seam and the perimeter.
2) If there is no vertical seam or intersection, then attach the ring/hook to a horizontal seam in the piece.

Problem: My solder has a white chalky growth on it. What did I do wrong?

Solution/Explanations:

1) All of the flux was not washed off of the project after it was soldered.
2)The project was not sealed with a finishing compound or wax, or it has worn off. Use 000 steel wool to remove the patina and any remaining wax. Clean the project thoroughly paying special attention to the corners and edges. Reapply the patina and wax.
3) The project has been exposed to the outside elements. Most waxes are intended for indoor use only. Others can be used outside, but must be reapplied regularly. Projects that will be exposed to the elements are better constructed using the lead came method.

Glossary of Soldering Terms

Antimony

An element used in the production of some solders. It should be avoided for use in stained glass.

Ceramic Heater

A type of heating element comprised primarily of ceramic, noted as extremely fast heating and efficient.

Chisel Tip

A soldering iron tip shaped like a chisel tool. This is the most common shape used for soldering stained glass. Chisel tips are made in a variety of sizes, the most common being 1/8”, 1/4” and 3/8”.

Heat Sink

A device used to draw or absorb heat being generated by another source. For example, an object being soldered acts as a heat sink to the soldering iron.

Decorative Soldering

Any decorative effects created in solder. These effects are created with a soldering iron, usually with a very narrow tip. Special solder, like 63/37 or QuickSet, make it easier to create special effects because it has a “zero” pasty range.

Eutectic Point

An exact single temperature point at which an alloy goes from solidus to liquidus with no pasty range. For example, the eutectic point of lead and tin is 361^0 F. This point is obtained only by 63/37 tin/lead alloy.

Flux

A chemical agent used to remove compounds from the surface of metals during the soldering process. (See organic and inorganic flux.)

Idle Temperature

A very low temperature at which the iron is on, maintaining the capability of a more rapid heat up than if the iron was off or “cold”. This is usually between 200^0F and 300^0F.

Inorganic Flux

A flux comprised of one or more inorganic salt such as zinc chloride or ammonium chloride. Inorganic fluxes are more corrosive and conductive than organic fluxes,. They are effective on all common metals.

Leaded Solder

A material used to join metals comprised of tin and lead.

Liquidus

The temperature at which a pure metal becomes completely molten or liquid.

Mica

A mineral based material used as a construction component in wire wound type heaters of soldering irons.

Organic Flux

Organic fluxes are not as corrosive as inorganic fluxes. They are often used when the surface of the glass may be effected by the flux, such as painted glass.

Oxides

Debris on the surface of a metal which is the result of the reaction with chemicals in its environment. Oxides must be removed mechanically (with steel wool or a brass brush) and chemically for proper wetting to occur.

Pasty Range of Solder

The temperature range which is the difference between the solidus and the liquidus temperatures. This is sometimes referred to a the "working range".

QuickSet™

Another name for 63/37 solder. See decorative solder.

Recovery Time

The time required for a soldering iron to reach soldering temperature after it has hit a "cold spot".

Rheostat

The term applied to a soldering iron control which is used to vary the temperature of the heater in the iron.

Solder

An alloy of two or more metals with a liquidus temperature of less than 800^0 F.

Solder Bead

The term used to describe the look of solder when it has been properly applied to a copper foil seam.

Solidus

The temperature at which a pure metal or alloy goes from liquid to solid (or "freezes").

Temperature Control

An electrical or electronic device into which a soldering iron is plugged, or which is within a soldering iron. The device is used to vary the temperature of the soldering iron heater.

Tinning

Applying a thin layer of solder to a metal surface. Most commonly used in reference to the copper foil technique.

Tinning Block

A block of sal-ammoniac on which a soldering tip is cleaned and resurfaced with a layer of solder. It is not actually used for soldering.

Tip Tinning

The process of renewing a soldering iron tip using a sal-ammoniac (tinning) block.

Wetting

The term used to describe the proper flow of liquid solder, promoted by flux, on the surface of another metal. "Wetting" is necessary to form a proper soldering joint.

Wire Wound Heaters

Soldering iron heaters constructed with heating wires wound in a coil around Mica.

Soldering & Desoldering

Soldering/Desoldering Tools & Accessories

Soldering Station with LCD Display, ESD Safe 400 Series

17400

- High-quality sensor and heat exchange system guarantee precise temperature control at the soldering tip
- Soldering iron tool heats rapidly from room temperature to 350C in 30 seconds
- Suitable for general purpose soldering as well as specialized lead-free soldering applications
- Sponge and coiled brass tip cleaner ensure a clean soldering tip free from debris and corrosive material
- Strong, deluxe iron holder provides safe secure place to store heated iron between uses

Product ID	Description
17400	Soldering Station with LCD Display, ESD Safe 400 Series

Soldering Station with LCD Display, ESD Safe 405 Series

17405

- LCD temperature control display with blue backlight
- Long lasting, durable high - quality ceramic heater
- Sponge and recessed area provides a convenient method for cleaning the tip
- Suitable for general purpose soldering as well as specialized lead-free soldering applications
- Safety guard iron holder

Product ID	Description
17405	Soldering Station with LCD Display, ESD Safe 405 Series

Soldering Kit - 6pc

17501

- 40 Watt Soldering Iron heats up to 900° F
- Ideal for use on electrical/electronic components, audio equipment, etc.
- Includes desoldering pump for removing liquid solder
- Provides basic tools needed for many soldering projects
- 6 Pc kit comes complete with replaceable fine tip

Product ID	Description
17501	Soldering Kit - 6pc

Soldering Kit - 7pc

17502

- 40 Watt Soldering Iron heats up to 900° F
- Ideal for use on electrical/electronic components, audio equipment, etc.
- Includes desoldering pump for removing liquid solder
- Provides basic tools needed for many soldering projects
- 6 Pc kit comes complete with replaceable fine tip

Product ID	Description
17502	Soldering Kit - 7pc

Soldering Iron 80W with Fine Tip

17510

- Ideal for general purpose soldering applications including metal board, tube or large components
- Round, soft grip, non-slip handle
- Durable cord with a 5-foot reach
- Fitted with long life replaceable fine tip

Product ID	Description
17521	Soldering Iron 40W with Fine Tip

Soldering Iron 40W with Fine Tip

17521

- Ideal for general purpose soldering
- Round, soft grip, non-slip handle
- Durable cord with a 5-foot reach
- Fitted with long life replaceable fine tip

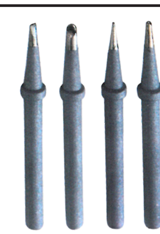
Product ID	Description
17521	Soldering Iron 40W with Fine Tip

N-Series Soldering Iron Tips

- Long life, lead-free soldering iron tips
- Replacement tips for soldering the different components of PCBs
- Five different sizes
- Includes two tips
- For use with 17400 & 17405 ESD Safe Soldering Stations with LCD Display

Product ID	Description
17400-N9-1	N-Series Soldering Iron Tips (N9-1)
17400-N9-2	N-Series Soldering Iron Tips (N9-2)
17400-N9-3	N-Series Soldering Iron Tips (N9-3)
17400-N9-4	N-Series Soldering Iron Tips (N9-4)
17400-N9-5	N-Series Soldering Iron Tips (N9-5)

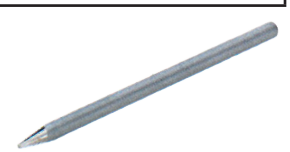
C-Series Soldering Iron Tips



- Long life, lead-free soldering iron tips
- Replacement tips for soldering the different components of PCBs
- Four different sizes
- Includes two tips
- For use with 17521 Soldering Iron 40W

Product ID	Description
17521-C1-1	C-Series Soldering Iron Tips (C1-1)
17521-C1-2	C-Series Soldering Iron Tips (C1-2)
17521-C1-3	C-Series Soldering Iron Tips (C1-3)
17521-C1-4	C-Series Soldering Iron Tips (C1-4)

B-Series Soldering Iron Tips



- Long life, lead-free soldering iron tips
- Includes two tips
- For use with 17510 Soldering Iron 80W

Product ID	Description
17510-B5-1	B-Series Soldering Iron Tips (B5-1)

SMD Soldering

Your reference guide to soldering with surface mount devices

Edited by Lim Siong Boon, last dated 06-May-09.

email: mail@siongboon.com
website: http://www.siongboon.com

Short cut to your reference guides and charts

1. Introduction to SMD soldering

SMD IC stands for surface mount device integrated circuit, or commonly known as SMT surface mount technology. Why go into SMD? Small in size, light in weight. This is the advantage of smd. Being small, engineer is able to design small electronics gadget that people can carry around. It is quite obvious that people prefer small mobile phone.

The ultimate advantage will be lower cost to consumer. Being small in size, the printed circuit board (pcb) can be small, meaning low cost. Transportation cost can be reduce because it is now lighter and more products can be packed into the same box. Space required is less, meaning cost saving on the warehouse storage. PCB board is easy to route without the through hole. Better signal integrity. Easily assembled by machine. There is too much advantages. Going SMT is certainly the way forward.

Technology evolution, from big to small.

A phone small enough to carry around.

Smaller mobile phone

Even smaller phone

Mobile phone as thin as biscuit.

I used to build circuits using dual in-line package (DIP or DIL) IC only. I hardly thought of using surface mount device/component (SMD) because I have great doubt that I can solder the fine legs of the IC chip. The pitch for the older DIP IC package are 2.54mm. Pitch is the distance between adjacent pins as illustrated in the picture. Most IC comes with a variety of packages. The IC that I know of, offer both the SMD and DIP packages. I

Through hole packages

	DIP - 8 pins

thought that I will never ever need to use smd packages until one day, I have no more choice. I managed to pick up new circuit designs, and discover more and more new IC chips. Most new IC chips design do not have DIP packages. You can hardly find one. I realised that in order to implement better circuits, I need to learn to use new IC chip. In order to use the new chip, I have to find ways to solder smd components. That's where I venture into the world of smd.

Nowadays people prefer to use smd, because they are small in size, which turns out to be cost efficient fabricating small PCB. With smaller PCB, space & weight is saved, resulting in lower cost for the transportation/distribution and storage.

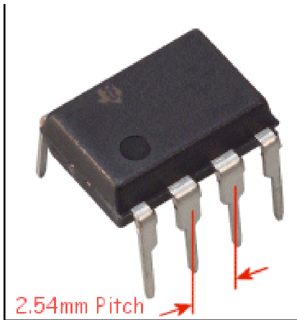
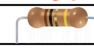
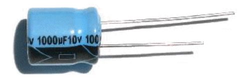
Research and research, I got to know from other electronics guru that smd is in fact easier to work with than through hole. I try it out and from that day onwards, I am in love with smd components. Small to solder, but it save me the effort to cut the lead for through hole component. I managed to store my component using minimum box and space. There are many many advantage to work with smd.

Many people might think that you need special tools like a rework station or fine tip iron to solder the small smd components with small pitches. With the correct technique, you can use your soldering iron to do the soldering. In fact my 60W goot TQ-95 soldering iron has quite blunt tip. So thick that most people think that it is not possible to solder smd IC with fine pitches. Fine tip iron is easy to reach the fine lead, but I find that it is not as hot as the same iron with blunt tip. If you prefer fine tip, I will recommend hotter soldering iron or those which can allow you to adjust the temperature, they can be hot. I managed to solder smd package TQFP, SSOP QSOP with pitch as small as 0.5mm. Width of the lead of about 0.3mm.

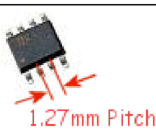
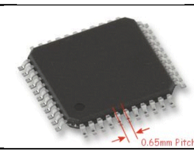
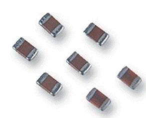
Dealing with SMD components do not necessary requires you to fabricate a professional pcb board. You can also mount smd components on low cost prototyping board. To start off implementing smd components, you might like to try using the soic package. Quite common at this point in time, but may just phase out as what has happened to the dip packaging. SOIC has a pitch of 1.27mm, which is exactly half of DIP packages. This size is great because I can solder the IC to the same old 2.54mm pitch prototyping donut padded board. What I usually do is to cut the donut pad into half. Soldered onto each pad is two pins 1.27mm apart.

You can refer to the following article, for further illustration.

"SMD soldering (prototyping board)"

	
	resistor
	capacitor
	inductor
	diode

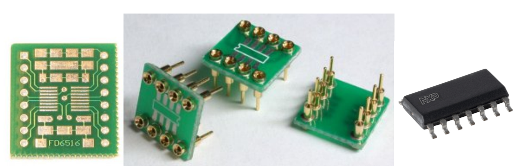
SMD packages

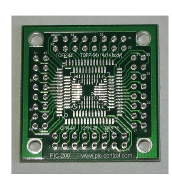
	SOIC - 8 pins
	TQFP - 44 pins
	resistor
	capacitor
	inductor
	diode

With so much advantage there is indeed a disavantage. SMD IC comes with many type of packages with different pitches. Unlike DIP IC, the pitch is typical 2.54mm. I can easy purchase a prototype board with 2.54mm, and almost all the DIP will fit to the board. SOIC package can still be mounted onto the 2.54mm prototype board. The rest of the SMD IC chip has quite a wide range of completely different packaging. This make them difficult to start with, without having to fabricate a PCB.

There are actually solution to this. Most IC company usually introduce their IC chip together with a prototype board for the IC.

Another solution will be to use a pre-fabricated prototyping board that allows mounting of various smd footprint. You can search for the various names such as





Various distributor for the prototyping adaptor

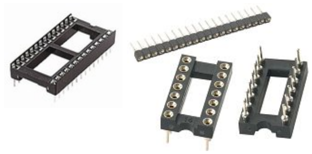
- prototype adaptor
- chip adaptor
- smd prototyping board
- smd to dip adaptor
- smd socket
- smd adaptor
- smd to 2.54mm converter
- SMD to DIP converter
- chip carrier

BELLIN DYNAMIC SYSTEMS INC
ROTH ELEKTRONIK®
AVRMALL.com 개발보드전문 전자쇼핑몰
FOREST CITY PCB
Elk Tronic
PIC control
Farnell
RS

You can refer to the following article, for further illustration.

"SMD soldering (prototyping PCB socket 2.54mm pitch)"

In prototyping with DIL IC, pcb mount IC socket is usually used, so that the IC can be removed easily if damaged. Some sockets are designed for programming used where the chip can be inserted and remove easily for programming purpose. To remove the component, you need not have to do de-soldering. Like DIL package, smd also comes with their own IC socket. There are many variety of smd packaging, and getting the socket for your smd components is not going to come cheap & easy compare to DIL. Therefore I usually built prototype without any sockets for smd design. After numerous attempts designing and building of circuits, you will definitely attain a certain level of confident on your design without considering IC socket. Without the socket, cost and space are saved significantly.



DIL IC sockets/ holder. Turn pins designs is of better quality.

SMD IC sockets:

Various distributor for SMD socket

Ironwood Electronics
Logical Systems
ARIES ELECTRONICS, INC.
AVRMALL.com 개발보드전문 전자쇼핑몰

The headache will come when you really need to removed the smd IC. How do you remove the IC from the PCB? For de-soldering of smd component more than 3 leads, you can add in more solder to connect up the IC pins heat pins on all the sides of the IC and eventually pull out the component. It is easier to use the rework station or IR heater to de-solder smd components. The rework station uses hot sir to melt down the solder on the board. You will need to aim the hot air at the solder joint.

Rework Station

Various type of smd packaging

* SOT, SC

* SOIC, ExposedPad™

* SSOP, ExposedPad™

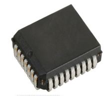
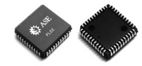
* TQFP, ExposedPad™

* TSOP

* TSSOP, ExposedPad™

If you do not have the lurxy of getting the rework station, another possible method might be to use a special solder that has lower melting point. LowMelt® DeSolder Wire. A lower melting point means that the solder will takes a longer time to cool down to a solid. This allows you more time to remove the IC after heating up the solder. The solder is flooded onto the pins of the IC. The pins are heated up together using a soldering iron and the smd IC can then be removed easily with a tweezer.

Low melt solder wire

 * PLCC 

 * LQFP, ExposedPad™

* LGA

 * PBGA

 * PSOP

 * Dual Row MicroLeadFrame®

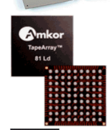
 * LQFP PowerQuad®

 * MicroLeadFrame® (MLF®)

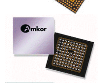
 * MQFP PowerQuad®

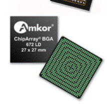
 * PSvfBGA

 * SuperBGA®

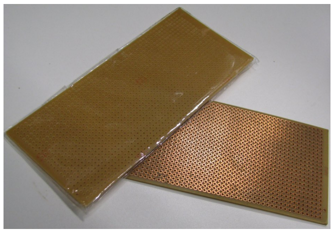
 * TapeArray® BGA

 * tsCSP

 * Ultra CSP™

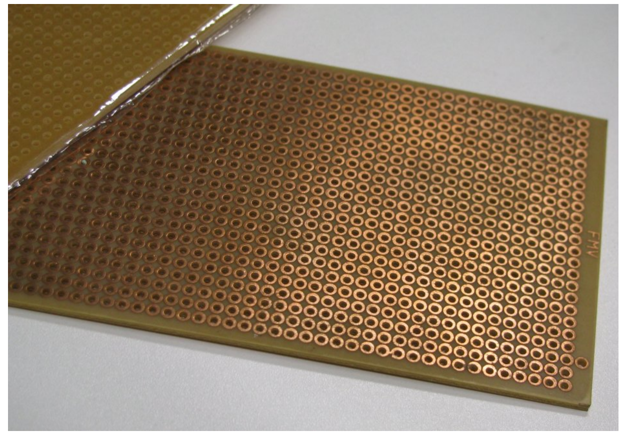
 * CABGA, CTBGA, CVBGA

2. SMD soldering (prototyping board)

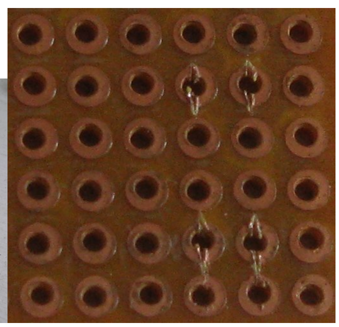


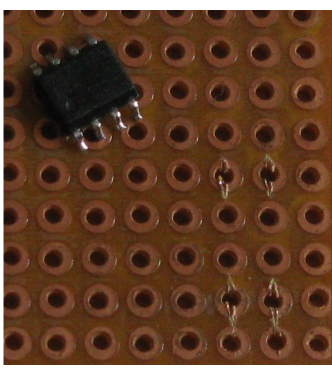
The prototype board above has pad with 2.54mm pitch and is designed for DIL and through hole components. The board is easily available from local store. Dealing with smd components on this 2.54mm pitch board is not difficult as well. I have been using this board to solder quite a number of surface mount components.

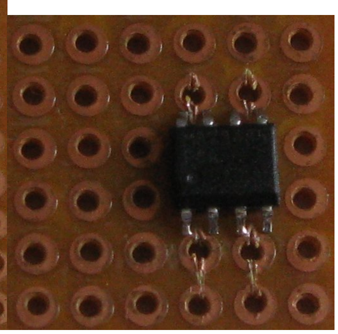
- SOIC
- DPAK
- SOT23-6, SOT-3
- TO-263
- PSOP



High pin count component with pitch less than 1.27mm will not be suitable to mount onto this board. For passive smd component like resistor, capacitor or inductor which only have 2 pin, mounting is simpler. Size is not an issue soldering onto the board.





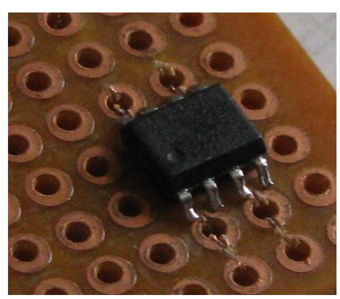


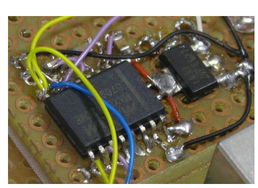
Align the SMD IC to the position on the pad. Mark out the pad for the cutting to be done.

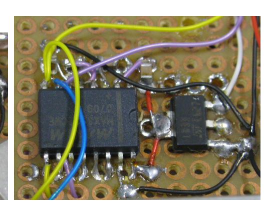
Use a penknife to cut the donut pad into half. Ensure that the half pad does not short circuit using your multi-meter. Sometimes the cut may not be deep enough or conductive reside between the gap resulting in a short circuit. Remember to ensure that each is proper cut before you start to solder.

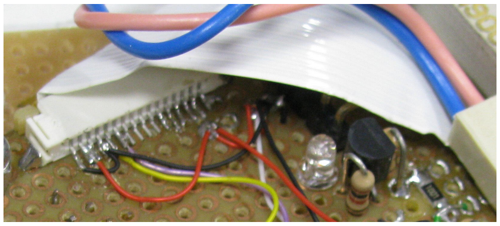
Align the smd with your finger or tweezer and begin soldering one of the pin. Check if the IC is still properly align after soldering the first pin. If not, heat up the soldered pin and realign again. After the ICis align, solder all the rest of the pin. If the solder bridge across to the adjacent pin, use a soldering sucker to remove the excess solder.

The cut between the pad usually make the solder harder to bridge across the adjacent pin. Bridging is still possible, and it is quite easy to have it removed.









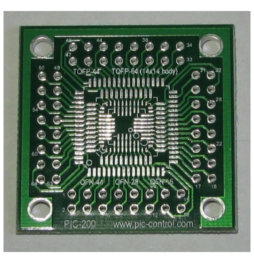
Example of building the circuit using surface mount component on the prototyping board with 2.54mm pitch pads. As shown above, the pins are being wired by fine wire wrapping wire. The single core wire is very flexible and comes in a variety of color, making it easy to identify the type of signal being carried by the wire.

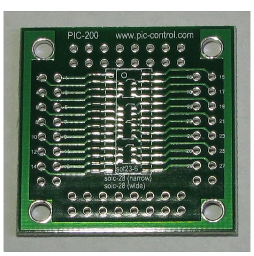
SMD ribbon cable connector being soldered onto the 2.54mm pitch prototype board.

3. SMD soldering (prototyping PCB socket 2.54mm pitch)

What you need...

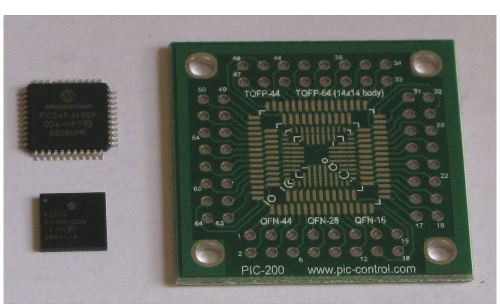
List of items:
- Surface IC chip (TQFP package)
- Surface mount IC adaptor or converter
- Soldering Iron
- Tweezer or Pincer
- Solder with flux core
- Soldering Flux
- Stick for coating flux
- Wiping paper
- Tinner





PIC-200 smd to 2.54mm pitch adaptor

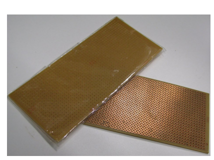
from PIC control.



INTRODUCTION

In this setup, I am going to solder a surface mount microcontroller (TQFP 44 pins) onto a smd adaptor. The adaptor will then be used on the commonly available prototyping board, so that I can try out my new design for circuit control.

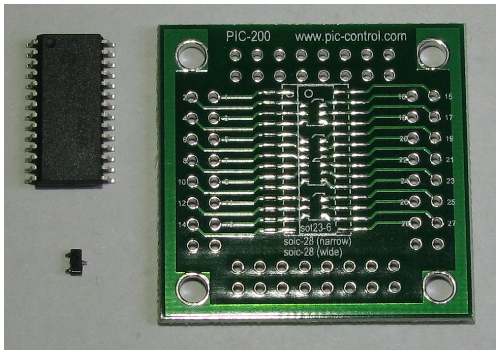
TQFP, QFN and SOIC are quite some common footprint for prototyping smd microcontroller from 18 to 64pins. This prototyping adaptor pic-200 (on the left) that I have is an ideal adaptor for my microcontroller. Converting the smd device into 2.54mm, I can easily mount the smd unit onto my 2.54mm pitch prototyping board. It is available locally.

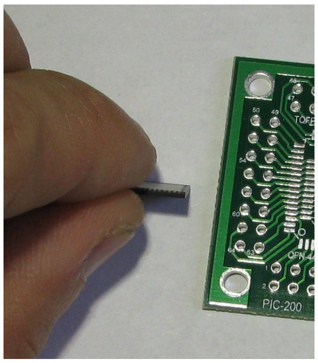


Prototyping board with 2.54mm pitch donut pads.

The pic-200 smd adaptor originate from PIC-CONTROL and is well documented. Commonly used smd footprint can be found on either the top or bottom side of the pcb adaptor. These are some of the smd packages that can be mounted onto pic-200 adaptor.

IC	Front	Back
TQFP-44		



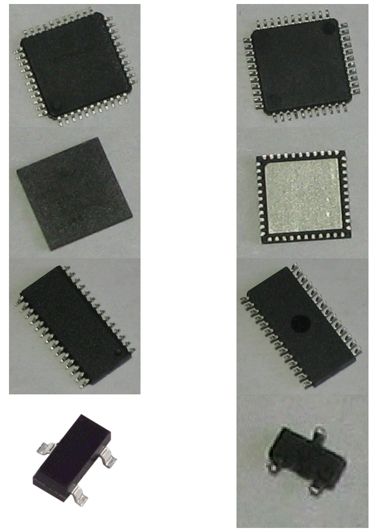


Holding onto the side view of the QFN package IC.

QFN-44

SOIC-28

SOT-3

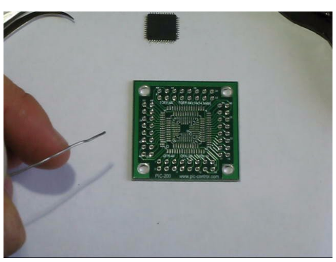


With a wide range of smd components that can be mounted, it is easier to stock up this pcb adaptor for future prototyping use.

The following article is about getting my smd microcontroller PIC24FJ64G004 soldered onto this board. After which I will be on my way to do prototyping for my new control circuit.

This smd adaptor origined from [PIC-CONTROL](). For other type of adaptors, you can also refer to other manufacturer as mention [above]().

<Step 1>



Before soldering, ensure that the soldering pad on the PCB is free of oxidation. PCB is usually tinned to protect the copper surface from oxidation. In cases where the surface is oxidized, you can try cleaning the surface with a contact cleaner. Apply the solution with tissue paper or toothbrush to clean up the contact. This solution make the PCB board rather oily, which I don't quite appreciate.

Contact cleaner.

Let us start our smd soldering here. Soldering surface mount component. The first important thing to introduce would be the solder.

There are many type of solder. Choosing the correct solder takes a bit of some knowledge too. Leaded or lead free solder? The industries is moving towards Pb free components & PCB, calling for unleaded product. Lead is toxin and not environmental friendly. I would advise ou to wash your hand after soldering or

handling pcb board. A soldering fume extractor to vacuum the smoky fume would be quite comfortable for your soldering. The smoke is quite choking and a health hazard if you breath that in.


soldering fume extractor.

Solder also comes with a variety of metal alloy combination. Nowadays it is common in solder core to contain flux. If the solder do not have the flux in the core, the flux have to be manually applied onto the metal surface before the soldering beginning. The flux cleans up the soldering surface, and also make the solder flow rather smooth like liquid. One of the important ingredient to make a good solder joint lays in the soldering flux.

Solder wire also comes in a wide range of diameter to choose from. Generally I use 0.8mm soldering wire roll with flux at the core. Smaller diameter solder wire allows you a better control of the amount of solder to apply. For soldering larger pins or connector component thicker diameter wire will be preferred. Wire too thin is rather troublesome, because you need to feed in a longer length of solder in order to solder the large surface/lead. For general purpose PCB board soldering 0.8mm wire fits somewhere in the middle. Not too thick nor too thin. For smd components, diameter smaller than 0.8mm is preferred. Using 0.8mm for smd soldering is not of any issue.


Solder wire 2mm

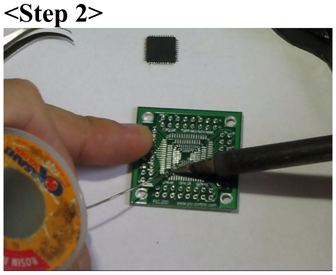

1.2mm

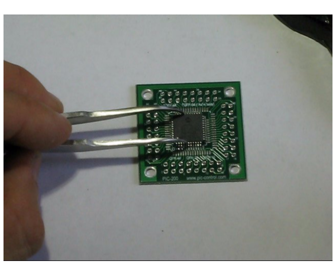

1.0mm


0.8mm


0.5mm

<Step 2>


One of the pad being tinned.


Align smd IC to the respective pad.

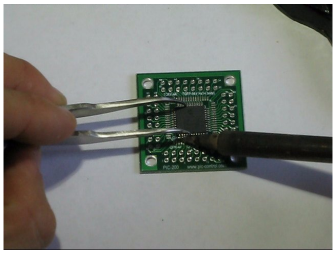
My microcontroller TQFP package has 44pins around the square package. To secure the package to the adaptor, I will need to solder one of the pin to the board first. It is important to solder only one pin. In case of mis-alignment, we can correct it easily. If more pins are soldered, it will be more difficult to correct any alignment.

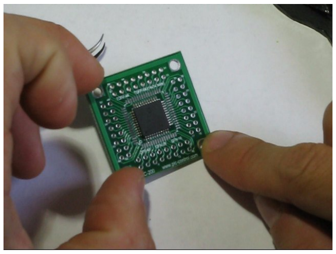
Pin 1 of the adaptor pad is first tinned with a layer of solder. A tweezer is then used to align the IC chip on the pad. The IC is secure to the board with a slight touch from my soldering iron, soldering the IC pin to the pad.

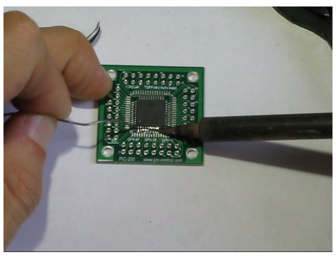
The important factor to consider would be the heat generated by the iron. I prefer to use a 60W iron, which still works well in air-con room. A lower wattage or fine tip iron will not heat up that well in colder environment.

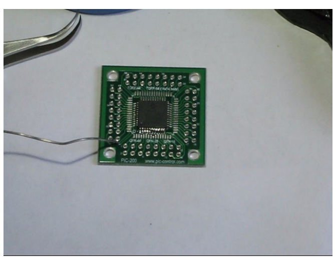

Goot TQ95 60W

If you prefer a fine tip, perhaps the soldering station will be more suitable. The iron temperature can be adjusted to a higher or precise temperature for the component that you want to solder. Component with thick metal contact like connector, heat sink, for thick cables should be solder with a


IC being fixed in position


Checking if alignment is correct.


Flooding the pins with the rest of the solder.


Pins flooded with solder

higher temperature. The iron should be held on longer, in order to have the component fully heated up before any solder is applied.


Solder Station

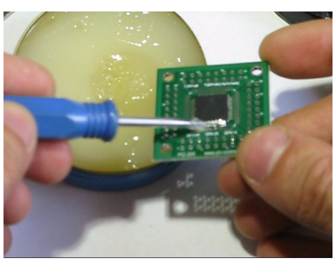
For soldering the IC pin to the pad, you can start off by heating up the pad. Then while heating up the pad, touch the IC pin and apply the solder wire directly to the pad or IC pin, allowing the solder to flow like liquid. The IC pin is heated last to minimize the chance of over heating the pin. If it doesn't flow very well, you can manually some flux to the joint. The solder wire should not touch the iron directly, because this will vaporize the flux, and solder flow will be restricted.

Heat up the lead and pad longer allows the solder to flow and form a good joint. Not for too long as it can also damaged your IC. You should be able to see the solder flow eventually onto the lead & pad. With a bit of practice, you will see the difference between a quick solder touch and another one with lead & pad heat up a little bit longer. It takes a number of practice to get a good joint with minimum amount of heating time.

The soldering iron that I use has rather thick tip, but that does not matter when I do soldering for the smd microcontroller. All we do is to flood the pins with solder. They can be be suck up later.

There is a technology known as ultrasonic soldering. The soldering iron tip has this micro vibration which helps the solder to flow more easy without much use of flux. It can also solderthose difficult to solder material. The following is one article that I found that describe about it. [- Soldering the unsolderable].

<Step 3>



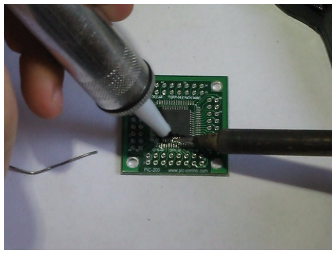
I have applied more flux at this stage. It should have been applied before flooding the pin, but it doesn't matter too much. The flux will make the solder rather liquid so that it is easier to suck up the excess solder.

solder flux paste

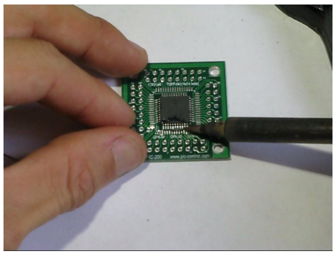
Baker Soldering Fluid

<Step 4>

The flooded solder is being heated up, and the excess solder are being sucked up.



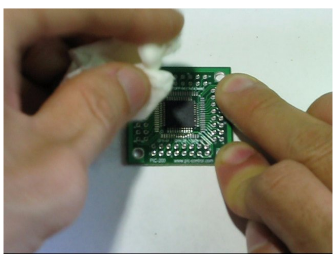
<Step 5>

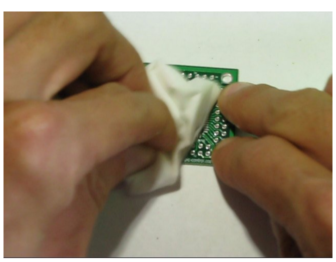


Each pins is being touch up, ensuring that the pin is solder to pad and that they are not bridged across to the adjacent pins.

Now we have got our smd component soldered onto the board.

<Step 6>





The flux helps a lot in doing a good solder but it often leaves the board with tiny dots of transparent strain, a bit sticky, also known as grease or flux residue. The board looks untidy with these tiny bits of grease.

These are the various recommended cleaning solution for pcb.
- 50% Alcohol + 50% Water
- Thinner
- Flux remover
- Multicore Prozone MCF800
- Solvent-> Bromopropane; propane, 1-bromo-; propyl bromide (Chemical Formula: C_3H_7Br)

Alcohol MSDS (Material Safety Data Sheet)

Thinner MSDS (Material Safety Data Sheet)

Electrolube, FLU Fluxclene Cleaning Solvent, pdf file

MG Chemicals 413B Heavy Duty Flux Remover

Brush for the crush

[Flux Remover]

[Multicore Prozone MCF800]

Besides using chemical, or after using chemical, there may still be some white blur stain. Those are flux spread dry up on the surface. Using a hot air blower, or heater on the surface can melt the dry up flux, and recover the smooth shiny PCB board surface again. Clean away the melt flux immediate after the heat.

Using alcohol is strongly recommended. Thinner is not suitable for certain plastic/material. Care is required when using thinner for cleaner. Using thinner on the PCB, copper pads and soldering joint isn't a problem. When use on plastic, you are advise to do a trial to ensure that the material is able to with stand thinner solution. Flux remover is commercially ready mixed solution. From what I learn in the manufacturer website, they are non-flammable chemical solution.

Alcohol & thinner has a lower flash point, and catch fire easily. You have to be extremely in handling and storing these flammable chemical. Do not store or work on the chemical near electrical appliances, hot area or things that can cause spark. Keep your windows open to allow air to circulate while working with these chemical. They may cause headache, dizziness and uncomfortable when inhaled.

Chemical comes in different level of grade. A slight different in the chemical concentration or purity can results in a large difference in cost. Alcohol can be expensive. For pcb cleaning purpose, request for technical grade alcohol. Higher grade alcohol is typically used for consumption or lab experiment purpose. Since we are using it for cleaning, there is not much advantage in using high quality chemical which is expensive. Dickson chemical is specialized in high graded chemical for laboratory use. They do sell lower cost technical grade alcohol. They are not suitable for consumption but is ok for cleaning application.

Dickson Chemicals

Dickson Chemical selling Technical grade alcohol

You can easily buy thinner from your local hardware. Typically used for cleaning your brushes after all the wall painting works.

The Science Of™ Zephyrtronics A Division of JTI, Inc.

Non-flammable Flux remover

click here to

Buy Cleaning Solution Now at the PIC-store

PIC-store

These are other recommendation in the web. After researching further, I would advise not use them. These chemical are of health hazard. Exposure will have severe adverse health effects.

- 50% isopropanol + 50% water
- Trichloroethylene
- Carbon tetrachloride

Isopropanol (true chemical name) is also known as Isopropyl alcohol or 2-propanol. 2- is refer as Iso. Other chemical may starts with 1- refer as N. These are some jargon used in the chemical industrial. I managed to learn a few of the terms from the vendor.
Trichloroethylene (true chemical name) is typically used for degreasing the metal. It is an extraction solvent for oil. Another name for Trichloroethylene is Trielin. Based on some read up, they can cause cancer.
http://www.answers.com/topic/trichloroethylene

Carbon tetrachloride can harm our environment, producing CFC which deplete the earth's ozone layer. http://en.wikipedia.org/wiki/Carbon_tetrachloride

Initially I tried using contact cleaner to clean the stain off. I use cloth or tissue but the fabric is often tear by the component sharp edges. Most corners are not easy to reach. Later on I tried using a toothbrush, the result is better.

For mass cleaning job, you can try using the ultrasonic pcb cleaner. It is a deep metal container for the solution, using micro vibration to shake off the dirt. I have never tried on it before, and I believe it is the same machine people used for cleaning their jewelry. Basically, you will need to dip the pcb board into the solution, and the ultrasonic will be activated to do it's job. The solution used is the same as manual cleaning, requiring 3-5 minutes of cleaning.


Ultrasonic cleaner

Ultrasonic jewelry cleaner



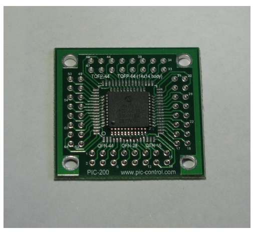
There is also a flux that does not leave residue on the PCB. I found it on the internet, and have not try it before.

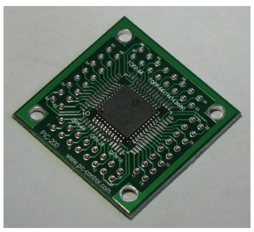
INTERFLUX, IF 2005M No-Residue™ flux, pdf file

Article relating to removing flux residue:

- pcb cleaning - Aqueous Cleaning Process.pdf
- pcb cleaning - Flux Removal, nuxx.pdf
- pcb cleaning - pcb cleaning article.pdf
- pcb cleaning - PCB Cleaning, Printed Circ.pdf
- pcb cleaning - pcb washing chemical composite.txt
- pcb cleaning - remove solder flux.pdf
- pcb cleaning - Solvent washing PCB boards.pdf
- pcb cleaning - washing the board using alcohol.pdf
- pcb cleaning - PCB cleaning article Inventec_S24_03.pdf

<Step 7>





A close up view of the clean and neatly soldered surface mount IC on the prototyping adaptor. Soldering smd components is simple and fast with a bit of practice. Small and easy to clean up. There are too many advantage in working with surface mount, compared to through hole components.

This is the end of the short demonstration on smd soldering. I hope these article can provide you some insight and confident to start experimenting circuits using surface mount components.

Video available. Please click here,
smd soldering.mpg (25MB)
smd cleaning pcb.mpg (5.5MB)

Article on smd soldering.
- 2010-07 How to Solder Surface-Mount Devices.pdf

Various Chemical Reference:

Alcohol 70% + Distill Water 30%
MDX4-4159
7MHFE-71DE

Cyclohexanone
Methylethylketone
ethylacetate,
Silicon Wacker
Wacker M4503, General purpose mould making silicon (Using Two Part Silicon Mold Putty to Make Molds)
http://www.kirkside.com.au/, Mould Material Specialist

Propanol, used to clean PCB. (close to white electric oil)
Acetone, remove away ink printed on PVC stickers
n-Hexane (white electric oil)

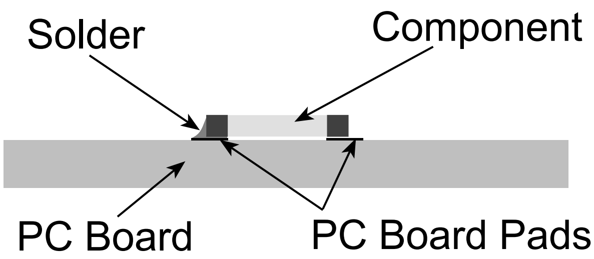
smd glue for surface mount component mounting / soldering use
Seal-glo NE series, NE3000S, NE8800T, more Seal-glo

email: mail@siongboon.com
website: http://www.siongboon.com

Keyword: surface mount soldering, smd adaptor, smd to 2.54mm convertor

Surface Mount Soldering Procedure

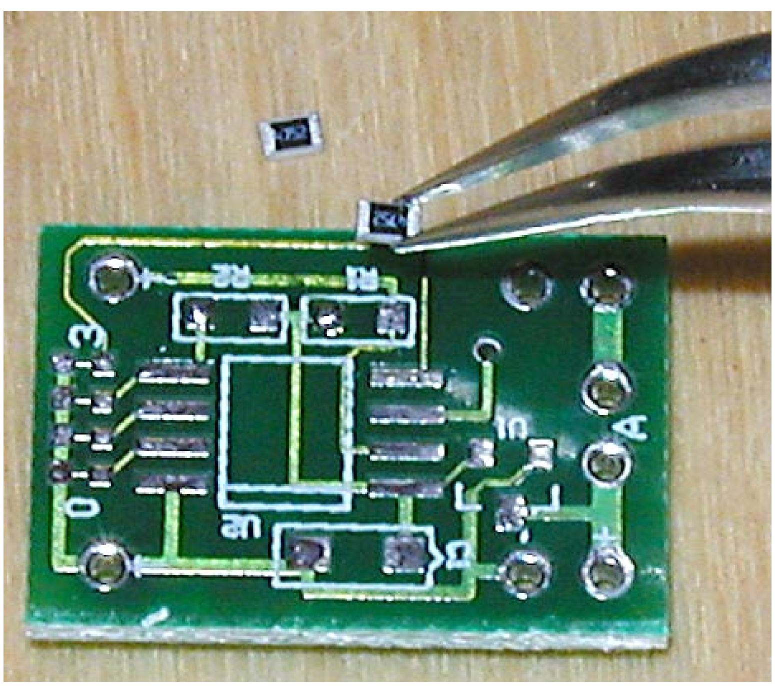
We believe that the following procedures describe the simplest way to reliably assemble surface mount components without special tools. The only tools required are a pair of fine-tip tweezers, a rosin based flux pen, rosin core solder (.025" dia. preferred), and a soldering iron with a small, clean tip. A spool of fine (0.075") solderwick will come in handy if you need to rework connections. You will need isopropyl alcohol, cotton balls, and cotton swabs for cleanup. If you have access to hot air rework tools and the skill to use them, feel free to use them instead.



A proper solder joint with fillet

Proper joints

Poor joints



Placing the component

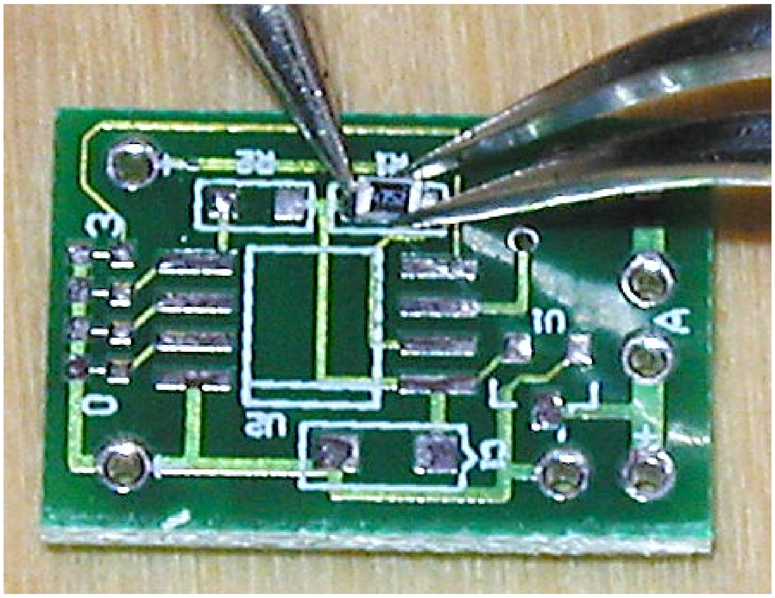
Soldering surface mount components is not difficult, but it does require good eyes, a steady hand, and a soldering iron with a small, clean tip. The illustrations at the left show a proper and a poor solder joint. In the proper joint, the flux has "wetted" both mating surfaces, allowing the molten solder to adhere to both the printed circuit board pad and the component lead. In the illustration of the poor connection, insufficient heat or flux has forced the solder to ball up on the end of the component, without making it to the PCB pad. The component is not attached properly, and the electrical connection will be intermittent at best. This connection can be salvaged by applying flux and heat to the PCB pad to get the solder to flow to the area between the pad and the component.

The most important characteristic of your soldering iron is that it must be equipped with a *small, clean* tip. If the tip is too large or is covered with oxidation, creating a well-flowed solder joint will be nearly impossible. Wipe your tip on a sponge before each joint - it must be shiny and well-tinned in order to transfer its heat properly.

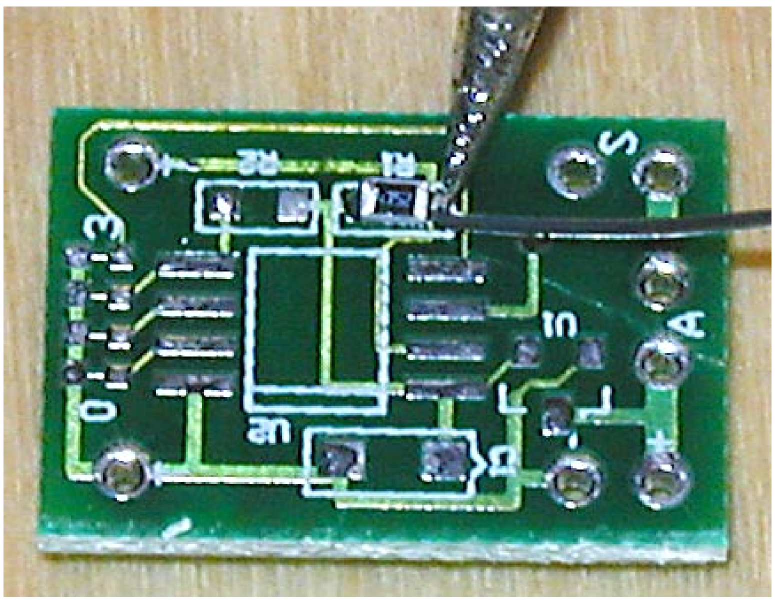
You will find it easiest to work on your board if you clamp it in a moveable vise or stick it to a small block of wood with double-stick tape. This will allow you to rotate the board to whatever angle is most comfortable for access to the component being installed. If you try to hold the tiny parts at awkward angles, you will not have good results!

The first step is to apply a small bead of solder to <u>one</u> of the PCB pads for the component to be installed (the left-hand pads of R1 and R2 in the photo at right). The bead should be approximately 0.020" to 0.030" high (you may want to reevaluate your bead size after you have completed several joints). Apply some liquid *rosin based* flux from a flux pen to the solder bead and to the other pad(s) for the component.

Next, using a pair of tweezers, pick up the component to be installed and place it over the appropriate pads.



Affix the part by reflowing the first solder bead



With the part in position, solder the other end

With the part in position, move the soldering iron to the solder bead on the PCB pad. Apply a small amount of heat from the iron to flow the bead, simultaneously lowering the part against the board and correcting for any rotational misalignment. Remove the iron and allow the solder to cool. Inspect the joint -- at this point you are not concerned about the quality of the actual solder joint, just the positioning of the component. The part should be flush against the PCB, with both ends properly contacting the pads. The part should be straight, and centered between the two pads.

Apply a liberal amount of liquid flux (again, a flux pen is the ideal applicator) to both ends of the component. Heat the currently unsoldered end of the component and the adjacent pad with the soldering iron, and carefully wipe on a small amount of solder. You want a small fillet as shown in the earlier illustration, not a large glob of solder. Make sure that the solder has flowed onto the pad as well as the component lead - don't be fooled by a lump of solder on the end of the component that doesn't flow under the component and onto the PCB pad.

After the second end is soldered, go back to the original solder joint and reheat the solder. The flux will allow the solder to flow freely, and a good fillet should be observed. If there seems to be insufficient solder, add a little more. If either of the ends appears to have an excessive amount of solder (a large blob sticking up above the part) it can be removed with solder wick. Apply flux to the blob and the wick, position the wick over the blob, and press lightly on the wick with your iron. As the heat is conducted through the wick the solder blob will melt and be drawn off by the wick. You may end up removing too much of the solder, in which case you can reapply a *small* amount of fresh solder to the joint.

After the joints have cooled, inspect them carefully to make sure that they are solid and make contact with the board. If you have any doubt about the quality of the connections, apply more flux and reflow the joints until you are satisfied.

The same procedure is also used for installing components with three or more leads (transistors, ICs, etc.). Start with a bead of solder on one pad, position and "tack" the part, then add more flux and solder the remaining leads. Don't forget to reflow/improve the first "tacked" connection if necessary.

Electrical Wire soldering For Beginners

by Randy Glass

DISCLAIMER- First, soldering can be dangerous. This lesson is not meant to be everything you need to know. Your safety is up to you, and you take full responsibility for any damage or injury caused by these instructions, whether as an act of omission or commission on your part or mine. Be aware that an improperly soldered wire can lead to fire, loss of vehicles, injury, and even death. By reading and/or using these instructions you take full responsibility and release me from all liability. Second, I took these photos as I did the work, pressing the remote control for my camera with one finger as I held the soldering pencil in one hand and the solder in the other. I apologize for any images that might be out of focus or poorly composed.

If Yogi Berra ever wrote a book on motorcycles he would probably say, "We seem to spend around forty percent of our time taking things apart, and the other seventy-five percent of the time putting them back together." Some things are easy to put together. We use specialized fasteners like nuts, bolts and screws to hold things together that, some day, we might want to take apart again. But there are some things that, once put together, we would like to know that, to some degree, our fastening system is permanent. One of those places is in electrical wiring. When a wire breaks or needs to be fastened to a connector or another wire in such a way as to be dependable, then the very best way is to solder.

soldering is a method to attach one metal part to another. It is part of a family that uses molten metal to do this job. At the top of the ladder is welding. This is a very high temperature method that actually melts the parts a bit where they are attached, along with some other metal, usually in the form of welding rods. Next is brazing. This melts some hard metal, usually brass, into the gap between two pieces of metal. Normally, the surface of the material being joined is not melted in this process, but it gets very, very hot. Finally there is soldering. soldering flows some molten metal between metal parts at relatively low temperatures.

For our purposes I am going to speak of the type of soldering that attaches two wires together or one wire to a connector- the sort of soldering that any backyard mechanic might need to do when working on any electrical component or the wires that connect them together in almost any type of vehicle.

WHY solder?

Although there are methods that can be used to make these connections without soldering, they are usually inferior. soldering does a lot of things:

1) It Is Strong- You are connecting two metal parts with a liquid metal that becomes solid after it fills the joint and cools. When properly done it leaves no voids so the joint is very strong and the wire is well supported.

2) It Slows or Stops Oxidation - Because solder fills the joint it excludes air and moisture so the metal in the joint will not oxidize. This maximizes electrical flow over time.

3) It Makes An Excellent Electrical Connection- because the solder is a conductor it gives the wire more area from which it can flow electrons to whatever it is connected.

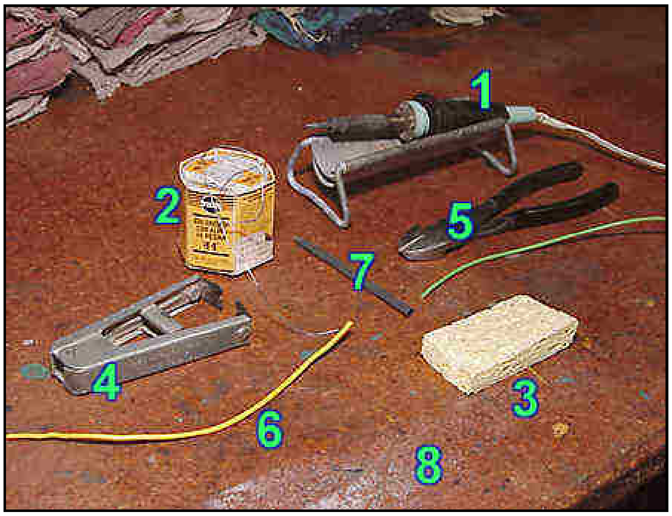
4) Non-permanent - Although soldering is very strong, it can be removed and the joint taken apart in the future if necessary.

5) Connectors do Not Need to be Crimped - Those little metal connectors that are designed to be crimped have a terrible habit of coming loose as well as breaking the little copper wires in the conductor making a weak joint as well as one that does not conduct as well as it should. They easily let air and moisture in which causes corrosion and that leads to poor and broken connections.

MATERIAL LIST

It doesn't take much to set yourself up as a soldering wizard. Here is a list (numbers refer to image to the left):

*1) **soldering Pencil -** Something around 25 to 40 watts would probably be fine for most electrical work. You don't need a huge soldering gun to do electrical work. A little smaller is actually better than too big, as we shall see. Get a brand-named pencil so that down the line you will still be able to



get replacement tips for it. A chisel tip as seen in the pictures that follow is best for most work but you might also need a pointed tip for more delicate work. Those old soldering guns are nice for making battery cables, but are generally too large for what we are doing. it would be like using a sledge hammer to make a picture frame- it would have to be a REALLY big picture frame!

There are also cordless, rechargeable soldering irons available. They generally run about $35-75 or so. Although these cost substantially more than a corded iron, and the replacement tips are more expensive as well, there is no cord to get in the way when working and as they can be carried along on trips. These generally have a built-in light as well making repairs at night easier. I normally loosen the lamp so that it does not light, so the battery lasts longer in use.

There are soldering tools that are actually little, refillable, butane-powered torches with a soldering tip at the end which is heated by the flame. As they are about the size of a fat ball point pen, they are another good way to get a portable soldering tool. These generally are available for less cost than the rechargeable irons mentioned above. I have used electric irons to solder around a gas tank on an automobile- something that I would never consider with one of these.

And a **soldering Pencil Holder** - Most soldering pencils come with a holder or a rest as seen here, but if not, get one. These metal stands are very handy and will help avoid melted parts and burned hands and work surfaces.

*2) **solder** - Resin core solder is what you want. NEVER use acid core solder on electrical components. The acid will stick around and continue to eat into components and wiring well after the soldering job is over.

Resin core solder can be had in various quantities, but I buy the one pound roll for around $12-15 which will be a lifetime supply for most folks. I use Kester brand "44" Resin Core solder in the .031 diameter size. This is about the size of mechanical pencil lead and works quite well for what you will be doing.

It use to be that a standard part of a soldering kit was a little tub of flux. This paste would be spread on the joint ahead of time to help clean the joint chemically as it was heated by the iron. It was necessary as flux-core solder was unavailable. If your wires are clean and you are using a quality, resin core solder, additional flux is not necessary.

*3) A**n Old kitchen sponge** or two

* **Tools** to work on wires such as a (4) wire stripper and a (5) wire cutter, and possibly needle nosed pliers and a small vise (not shown).

* 6) A few bits of **insulated wire** and an old spade connector or two on which to practice. Two or three feet of wire will do.

*7) **Heat Shrink Tubing** - I rarely use electrical tape any more. Heat shrink is really great! I usually buy it in three foot lengths in two or three sizes. This is a sort of memory tubing that, I believe, is made by heating a special tubing and stretching it and allowing it to cool while still stretched. it maintains that size. When heat is applied once again the tubing will shrink back down to its original size.

*8) Protection for the work surface like an old piece of 1/4" plywood about 12" square or such. An old piece of counter-top lamination works also.

* Wicking material (not shown)- You can purchase some special copper wick that is used to unsolder joints. This is usually not necessary, but handy at times, and inexpensive.

* **Eye protection**

* A Ventilated workspace

SOME WARNINGS

HEAT - A soldering pencil as well as molten solder are both really hot. They will burn you and it will hurt. It can hurt a lot. It can make your skin give off smoke and that smells bad. If left unattended a hot soldering pencil can cause fires, melt carpeting, burn workbenches, and make the cat dance like never before. An unsuspecting person can pick up a hot soldering iron and get a nasty burn (trust me on this one!). Never leave a soldering tool warming or hot and unattended.

Additionally, a hot soldering iron can almost instantly melt plastic parts and upholstery in a hurry. Use care when soldering as well as when moving the iron to and from the solder joint. If the cord gets caught when moving the iron it can easily cause you to drop the hot tool onto something expensive or painful. NEVER place a soldering iron on saddles, luggage, body work, painted surfaces, or on or near any heat-sensitive surface.

LEAD and VAPORS- solder contains a good amount of lead and handling it over a long period of time may have negative health consequences. The vapors caused by soldering can, over time, cause health problems as well. Work in a well ventilated area. I usually work out doors and use a fan to blow the vapors away from me. The smoke that is given off by the flux in the solder is also not a good thing to breathe.

MOLTEN METAL - When soldering (and particularly when un-soldering) it is very possible to flick bits of melted solder about. As this stuff is quite hot, even a small drop in the eye can cause permanent damage. Wear eye protection and do not wear your good glasses, or wear them under goggles. The dripped solder can melt plastic parts and permanently damage auto carpeting as well. Be aware of other folks or critters who may be in the area as well.

ELECTRICITY - You will be soldering on wires that, if shorted out, could cause a blown fuse, damaged electrical components, or melting wires and a fire. Always disconnect the battery when soldering wires on a vehicle and remove connectors from heat-sensitive components before soldering on them.

LETS GO

I could spend a lot of time talking about how it all works, but jumping right in is the best way to learn how to solder and I will explain as I go

Begin by creating a safe work area. One free of clutter, with sufficient light, and protected from the soldering iron and melting solder. Set the soldering pencil in its stand and plug it in. be sure that the cord is placed in a way that it will not be accidently pulled or tripped on, upsetting the soldering pencil.

While that is heating up, prepare your sponge. Wet it, squeeze out the excess water, then fold it in

half and rubber band it about half-way down.

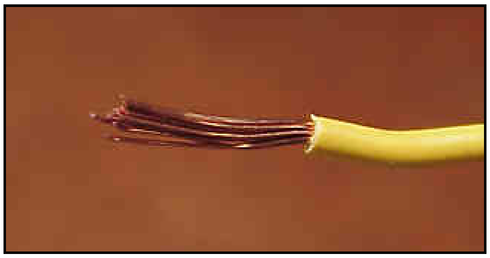
Pull out about a foot or two of solder from the roll and touch it to the tip of the soldering iron. Always apply the solder to the flat parts of the tip and not to the sides. When the solder melts fairly easily, melt an amount all over the tip. There will be some smoke from the resin in the solder.

The solder you bought is actually a bit hollow. Inside of the metal there is a channel (or in some cases, channels) that make it sort of like a little garden hose. The channel is filled with a resin. When heated it melts and some of it burns off. The action of the resin when it is heated helps clean the surface to be soldered which helps the solder stick a lot better. Unfortunately, the burned resins can also leave deposits on the soldering pencil, and over time will make it difficult to solder. That's where the sponge comes in. After you have melted some solder onto the tip (about a quarter inch or so of the thin stuff) wipe the soldering pencil's tip off on the damp sponge a few times.

If you examine the tip of the soldering pencil carefully you will see that it is now covered with a thing coat of shiny, silver metal- the solder. You have successfully "tinned" the tip of the pencil. This keeps the metal tip from oxidizing and will assist you in soldering from now on. Always do this before starting a soldering job and occasionally during a larger job.

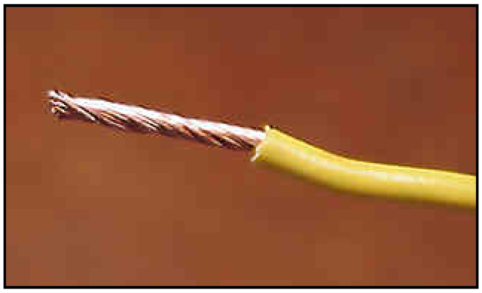
Place the soldering pencil back into its holder and let's prepare the wires. We are going to solder two wires together, making believe they have broken or need extending.

We start by "stripping" some of the plastic insulation away from where we want to connect the wires. The thicker the wire the more insulation we remove. For most common wires on a motorcycle or in a car, removing about 3/8 to � inch works fine. You will get a



feel for how much in a short period of time. When stripping wire be very careful not to cut the strands of the conductor.

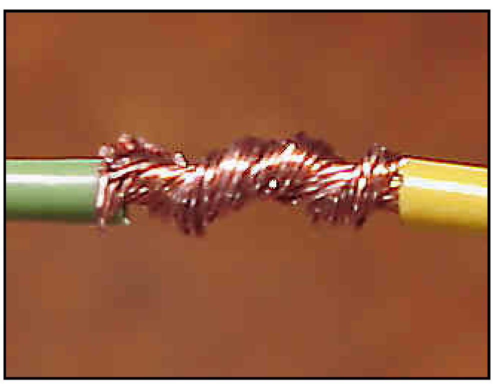
There are special tools available for stripping wire that can save a lot of time. These can be as simple as a carefully wielded razor blade to fancy and somewhat expensive automatic strippers.



Once stripped, twist the strands together into a neat little bundle.

The exposed wires should look fairly clean and in most cases, shiny, but certainly not green or cruddy. If corroded, then the wires should be cut back and re-stripped until clean wire is found.

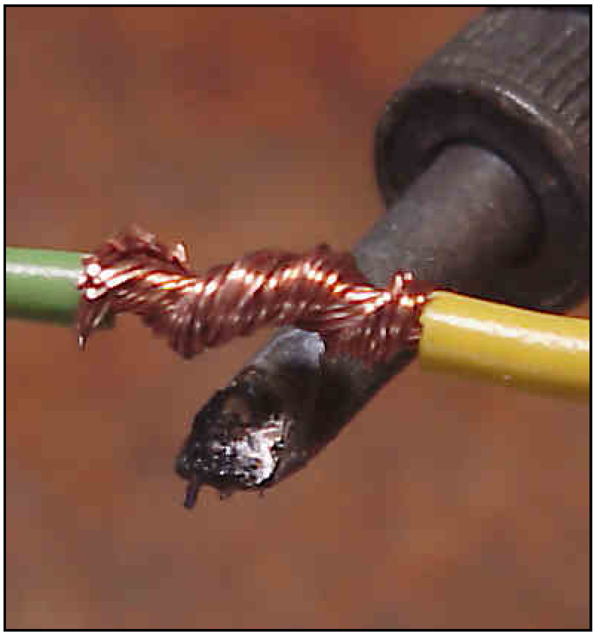
Now cut a length of heat shrink tubing off about an inch long. It should be of a large enough diameter that at least two of the wires you are soldering can easily fit into it at the same time. Slide the length of the tubing over one of the stripped wires- it doesn't matter which here, but in real life we would slide it over the lower wire or the one which slopes most downward away from the joint so it will tend to slide out of the way. make sure it is at least three or four inches away from the joint.



Now, twist the two wires together into a tight, neat pair. This is important because it helps create a good electrical connection. You also do not want any little wires sticking out. Start by crossing the wires about mid-strip, crossing them at about 45 degrees or so, and twisting in opposite directions. When done, the joint should be fairly strong on its own, holding the two wires together tightly. The connected pair of wires should be in line as if they are a single wire and not two joined together.

It's time to solder. Place the roll of solder on your left (if you are right handed) with a good length of solder hanging out of the roll. With the solder in your left hand and the soldering iron in your right hand, check to see that the tip is still tinned and shiny. If not, repeat the process with a bit of solder melted to the tip, then wipe the tip off on the sponge.

Melt a little ball of solder onto the iron....



...and immediately place the soldering iron under the twisted wires (if possible) so that the little ball of solder fills much of the gap between the soldering pencil and the wire. Since heat rises, placing the iron under the joint will heat it faster. The little ball of solder works as a heat conductor and will very rapidly conduct the heat from the soldering pencil's tip into the wires. If the ball of solder does not seem like it is contacting the wire very well, without removing the pencil from the joint, melt just a bit more solder in there by feeding the end of the solder wire into the tip. This will not only increase the contact area of the solder to the wire but it will also add a bit of flux that helps the solder adhere to the wire at this time.

After about two or three seconds, start to feed solder, slowly at first, into the void between the pencil and the wire. You should soon see the solder is flowing into the twisted wires. WHen that happens, increase the feed rate of the solder into the joint, and you can now also feed a little into the top of the joint. Don't move the iron's placement, jut take the end of the solder wire and touch it to the tip of the joint. Continue to feed solder until the individual wires are almost filled with solder and the entire joint has turned silver. When that happens, stop feeding the solder in and immediately but gently remove the soldering iron.

How long do you wait until feeding in solder? One way to test how long to wait is to touch the solder on top of the joint and wait until that area is hot enough to melt the solder. The amount of time it takes varies with the size of the wires to be soldered, the size of the solder, the wattage of the iron, the size of the irons's tip, the ambient air temperature, and other factors. Experience will teach you how long this takes.

The problem comes from waiting too long and putting too much heat into the joint. When you do that it begins to melt the insulation on the wires around the joint (you can see that beginning to happen above at the end of the insulation of the green wire next to the soldered joint). That is why I like tho flow the solder in from where the iron's tip touches the wire. This is the place that will come up to soldering temperature first, and then the flowing solder will more easily flow solder into the joint as it carries heat with it. The larger the wires, the longer it takes and the more important it

becomes to feed in some solder from the top of the joint as well. Again, experience will teach you when that is necessary.

How much solder is enough? Too much? The correct amount of solder is used when the joint is fairly all silver colored but still shows the "outlines" of the individual strands of wire in the joint. If there is very much in the way of copper colored wire showing then you probably didn't use enough solder or the wires weren't clean and would not accept the solder. If there are big blobs and drips of hardened solder on the joint then you probably had either too cool of a joint or used too much solder.

After soldering, let the joint cool for about thirty seconds to a minute or so before handling. If you were successful you should have:

* A pair of wires tightly joined together

* The joint between them is very shiny, looking like polished sterling silver.

* No hardened dribbles or drops of solder hanging off the joint

* No little wires sticking out of the joint.

* A union only slightly larger than each of the wires themselves.

If you were NOT successful you might see:

* Large blobs or possibly a long, pointy finger of hardened solder hanging off the joint. Sometimes, after cleaning the iron, these can be removed by simply heating the joint until the solder melts, then removing the iron which will pull away some of the excess solder with it. This may need to be repeated a few times to remedy the situation.

* Wires that are not soldered together and has movement within it. Re-heat the joint and add some more solder.

* Melted insulation. This can be so bad that the wires are revealed with the insulation dripping off the wires. At this point you will probably need to cut the wires and begin again, or unsolder the joint and add a long piece of heat-shrink tubing to cover the exposed wires.

* Little ends of the copper wires sticking out. These can sometimes be cut off with a wire cutter and/or pressed down with a pair of smooth-jaw pliers, possibly needle nose pliers.

Now it is time to cover the joint with the heat shrink tubing. You DID remember to slide on the heat shrink tubing before beginning, didn't you? Once the joint is cool enough to touch, slide the tubing so it is centered over the joint and gently touch the meaty part of the soldering iron's heating element to the center of the tubing.

Continue this around the center of the tubing until it tightly grips the wire joint, then work outwards until the entire piece of tubing has shrunk tightly around the joint.

Attaching An Electrical Connector

Besides connecting two wires together, soldering is the best way top attach some sort of connector to the end of a wire. The connection is strong as well as fairly well sealed against the elements. It works pretty much the same way as above...

Remember when we "tinned" the tip of the soldering pencil? We did this to apply a film of solder to the tip so it wouldn't oxidize and thus be able to more easily transfer heat. Now I am going to do the same with a piece of wire.

Here I am applying a good amount of solder ahead of time to this wire because I am planning on soldering it to a fairly heavy connector. This way, the wire will be "pre-soldered" and easier to attach, and will have less of a chance of melting the insulation.

When soldering a connector to the end of a piece of wire it is very helpful to use some sort of vise to hold the connector. A small pair of locking pliers or a pair of needle nose pliers with a rubber band around the handles to hold the jaws shut works well. Here I have locked a pair of locking pliers into a small vise to work as a "hands-free" holder. This not only allows me to use both hands to work but isolates me from the heat of the soldering process.

Remember that the heavy metal pliers will work as a heat sink, pulling heat away from the soldering joint, so it might take longer to achieve the proper heat level in the joint. That is why I have gripped the connector as far away from the area to be soldered as possible,

Be careful as the pliers may get hot near the tips and you might overheat the wire as well. Be sure to slide the heat shrink tubing over then wire BEFORE beginning to solder! If you leave it off and finish soldering, you will be left with the soldering job in one hand, the heat shrink tubing in the other hand, and a stupid look on your face. We call this, "Heat Shrink Tubing Syndrome."

Additionally, if you apply too much solder, particularly with a small connector, it is very possible to fill the connector with solder and thus make it difficult or impossible for the connector to function properly. There are ways to

get the solder out, but they are generally more difficult (or dangerous) than just chucking it and starting over. To keep this from happening:

* Never touch the area of the connector where you don't want solder to flow
* Orient the connector with the part where solder shouldn't flow, upwards (or Higher than the end where solder will flow).
* Apply solder sparingly and slowly
* Use a lower wattage soldering pencil
* Use a smaller tip on the soldering pencil

I sometimes use two pieces of heat shrink, one over the other, shrunk one at a time, in areas where extra protection is needed. This is particularly useful when soldering a connector to the end of a wire. I first shrink a small diameter piece about an inch long over the wire up to where it joins the connector as shown here. This acts as a strain relief as well as insulation.

Notice the small amount of flux on the connector ring left over from the soldering process. If you use resin core solder, this stuff is harmless to the electrical device. It can be brushed off with a small wire brush if you wish.

I then shrink another larger diameter piece about � an inch long over the connector to act as an insulating cover. In the case of something like a female spade connector, the entire connector except for the opening can be covered and protected in this way. If the heat shrink interferes with the connection, simply cut the offending part away with a razor blade being careful not to damage anything else including yourself!

In areas where the joint needs to be protected from corrosion, slather the terminal with petroleum jelly, or the special grease for this application.

Following these directions you will become a "master solderer" in a short period of time. It takes some practice to get a feel of how hot for how long with how much solder it takes to create to make a good solder joint, so get some scrap wire and practice before attempting to solder on anything important.

If there are any questions or comments, please feel free to E-mail me at frcn@cncnet.com.

Note by Duane; If you appreciate articles like this, I suggest that you thank Randy at the email address above.

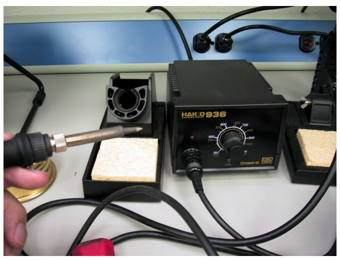
More BMW info

Home page

Soldering and Desoldering Instruction

Soldering is defined as "the joining of metals by a fusion of alloys which have relatively low melting points". In other words, you use a metal that has a low melting point to adhere the surfaces to be soldered together. Soldering is more like gluing with molten metal than anything else. Soldering is also a must have skill for all sorts of electrical and electronics work. It is also a skill that must be taught correctly and developed with practice.

Remember that when soldering, the rosin in the solder releases fumes. These fumes are harmful to your eyes and lungs. Therefore, always work in a well-ventilated area. Hot solder is also dangerous. Be sure not to let is splash around because it will burn you almost instantly. Eye protection is also advised.



The Tools

Soldering Iron – Even the cheapest of them will do the job. They may not last as long, but they do get hot enough to melt solder and that is the goal. You only need to make sure that the one you buy has a suitable tip on it. The most typical tip is the one that is about the size of a 1/8” stereo mini-plug.

Solder – Get Rosin Core solder. Rosin will help the solder to flow onto the wires. Solder comes in different thickness. Buy what is appropriate for your job.

Desoldering Gun – This tool will make life a lot easier when you need to rework a previous solder job.
Solder Wick – Braided copper with rosin coating used to draw solder off of circuit boards.

SMD Rework station— Basically this is a high temp hair dryer with special nozzle attached. It heats up entire pins of the SMD device so you can remove them.

The Methods

Soldering – There is not art to soldering, it takes patience and practice to get it right. If you are doing it right, it will be easy and very fast. First, make sure that your soldering iron tip is clean. If it is dirtier than just a light gray color, you need to clean it. You can do this with sandpaper or a Scotch Brite pad. Next, turn your iron on and give it plenty of time to heat up. To test the heat, use a piece of solder touched to the tip. If it melts immediately, it is ready.

The most common way to mess up a solder job is to let the soldering iron stay on the parts to be soldered too long. What this does is oxidize the metal, making it too dirty to attract solder. If you are working with a circuit board, too much heat can damage the board, rendering it useless and in need of repair. You should only hold the soldering iron to the parts to be joined for no more than 10-12 seconds. Any longer and you will melt insulation on wire or damage a circuit board.

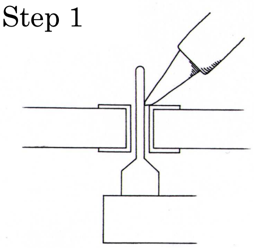
It has been said that soldering is a two-person job. You need two hands to hold the parts together, one hand to hold the iron, and another to feed the solder. The correct method for applying solder is to hold the joint perfectly still while heating with the soldering iron. After a few seconds, introduce the end of the solder at the point where the iron meets the parts

If the solder does not melt immediately and flow onto the joint, pull the solder away and try again after a couple seconds longer. If you exceed 10 seconds, pull the iron off and try again after it all cools down. You probably didn't have the iron touching enough of the parts to be soldered. Sometimes, the parts to be soldered are so big that they conduct the heat away very quickly and make it difficult to solder. In this case, it is OK to put some solder on each part individually and then put them together later by melting the solder on each one while they are touching.

Joining Two Wires - Strip off about 3/8" of insulation from the two wire ends to be joined. Place a ½" length of heat shrink tubing over one wire and push it back so that the heat from soldering won't shrink it prematurely. Fold each bare wire end back on itself so that the tip of the wire now comes back to the end of the insulation. Link both wires together using the bends like hooks. Now, twist the ends of the wires around themselves tightly. This type of connection is called a Western Union and it is the strongest method of joining two wires together. Now, heat the connection with the iron and allow solder to flow over the entire joint. Wait a few seconds for it to cool off and then slide the heat shrink tubing down over the connection and heat it with a match or heat gun.

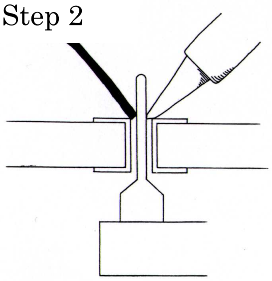
Soldering a Wire to a Circuit Board – This is delicate work that you will do while soldering. Too much heat and your board will be damaged. If you are attaching a wire to an existing hole on the board, make sure that the hole is clean and free of any excess solder (see de-soldering for more detail). The best advice when soldering to a circuit board is to angle your soldering iron tip so that it makes good contact with the pad on the circuit board and the wire or part to be soldered at the same time. Heat the parts up and touch the solder at the point where the tip meets the part and the pad. If the solder does not flow immediately, pull everything off and wait for it to cool down and try again later.

Step 1



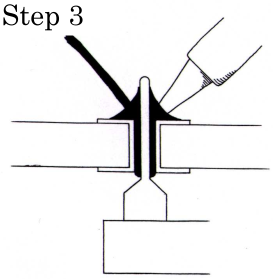
Apply heat to both pin and pad on the circuit board. Make sure tip of the soldering iron is touching both pin and pad.

Step 2



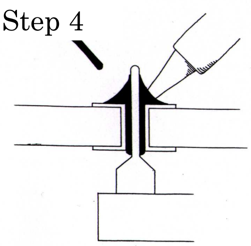
When the both pin and pad are heated enough, apply solder to the pin and pad. Solder should starts to flow.

Step 3



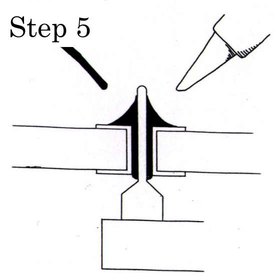
Apply enough but not too much solder. While applying the solder, do not move the tip of iron.

Step 4



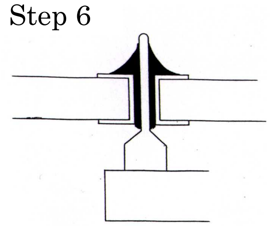
Remove solder away.

Step 5



Remove tip of soldering iron also.

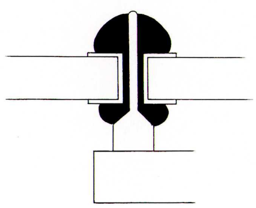
Step 6



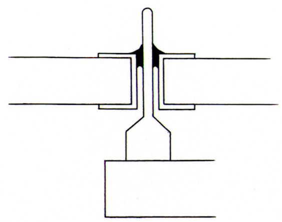
Done! Check the joint to make sure the connection.

Good soldering and Bad soldering Joints

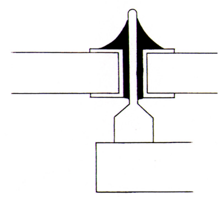
Here are some example of Good soldering and Bad soldering joint.
For Japanese, we often say, "Good soldering joint should look like Mt. Fuji."



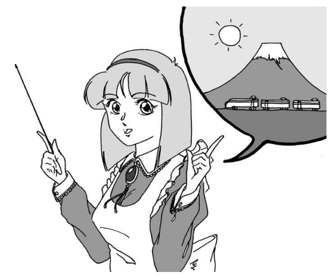
Too much soldering



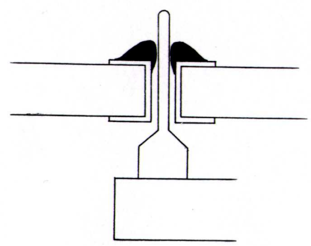
Too little soldering



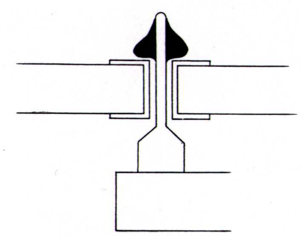
Good soldering



Cold Solder Joints
A cold joint is a joint in which the solder does not make good contact with the component lead or printed circuit board pad. Cold joints occur when the component lead or solder pad moves before the solder is completely cooled. Cold joints make a really bad electrical connection and can prevent your circuit from working.
Cold joints can be recognized by a characteristic grainy, dull gray color, and can be easily fixed. This is done by first removing the old solder with a desoldering tool or simply by heating it up and flicking it off with the iron. Once the old solder is off, you can re-solder the joint, making sure to keep it still as it cools.



Cold soldering joints



Tips and Tricks

Soldering is something that needs to be practiced. These tips should help you become successful so you can stop practicing and get down to some serious building.

1. Use heat sinks. Heat sinks are a must for the leads of sensitive components such as ICs and transistors. If you don't have a clip on heat sink, then a pair of pliers is a good substitute.

2. Keep the iron tip clean. A clean iron tip means better heat conduction and a better joint. Use a wet sponge to clean the tip between joints.

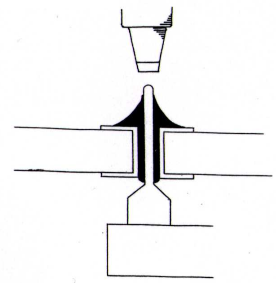
3. Double-check joints. It is a good idea to check all solder joints with an ohmmeter after they are cooled. If the joint measures any more than a few tenths of an ohm, then it may be a good idea to re-solder it.

4. Use the proper iron or temperature. Remember that bigger joints will take longer to heat up with an 30W iron than with a 150W iron. While 30W is good for printed circuit boards and the like, higher wattages are great when soldering to a heavy metal chassis.

Desoldering

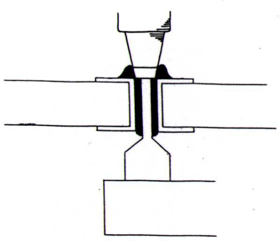
Desoldering is extremely difficult compare to soldering. In the process of RomBoard installation, the parts and circuit board must be in the good shape to re-use them. The tool we use is Desoldering Gun. This device has vacuum pump built in with heater tip. Process of desoldering it self is very simple, but there are some tricks to do clean and safe desoldering job.

Step 1



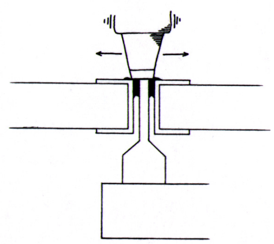
Put the desoldering gun's tip over to the soldering joint. Make sure nozzle is 90° angle from circuit board.

Step 2



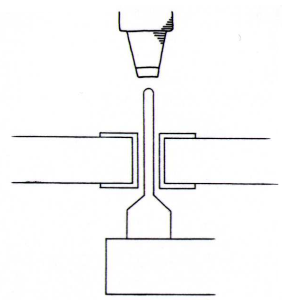
Apply the enough heat to melt entire solder. Multi-layer board or ground pin may take while to transfer heat.

Step 3



While applying vacuum, move the tip around the pin to get all the solder of around the pin out. At this time, you can also feel pin moves freely, so you know pin is free from circuit board.

Step 4

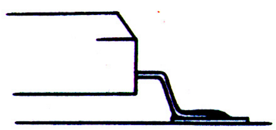


When you can hear air flow sound from hole, you should be done. Stop applying vacuum and remove the gun from the pin. Inspect hole and pin.

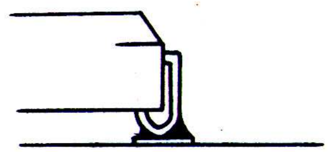
When you done with desoldering, the parts that you are trying to remove should move freely. If it doesn't, find which pin is still has solder left, and re-apply fresh solder to it and try desoldering process again. The multi-layer circuit board require more heat to get solder to melt. Make sure pin start to move freely by moving the tip of soldering gun before you apply vacuum to it.

SMD device soldering and removal

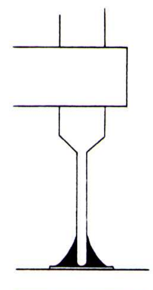
In the process of RomBoard installation, chance of handling SMD devices is becoming higher and higher due to ECU configuration change.
Soldering of SMD devices are not much different from regular through hole soldering.
Important thing is positioning of the device is very critical.
Start with applying little solder to two of the each corner of the pads on the circuit board.
Then, place the SMD device and re-heat a one of the solder you just applied to connect a SMD device pin to the pad. Check the position of the device, if position is right re-heat the other end of solder to secure the device completely. If you didn't get position right, re-heat the pin that you just soldered and while heating a pin, move the device to the right position.
Once you positioned the device in the right position, apply Rosin Flux to both pins and pads. This will help your soldering job by keeping solder separate from each pin.
Here is how the joint on SMD device pin should look like.



QFP and SOP chip

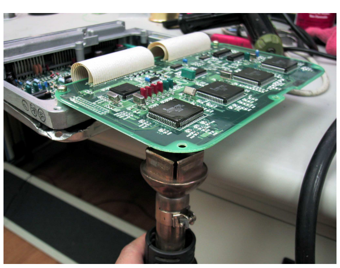


PLCC chip

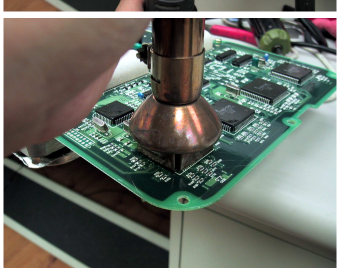


RomBoard adapter socket

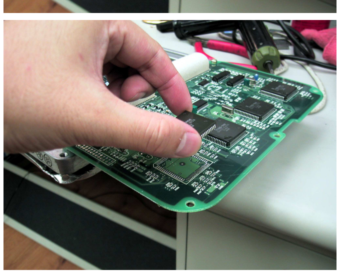
Removing SMD device will be the probably the most difficult process. SMD rework station is used to do this. Make sure all the pins are completely heated otherwise you will be removing a pad from the circuit board along with device. Also, you should note, when you are applying heat to the device, some parts around the device is also heated and moves around when you touch. It is good idea to take a note of location of the devices near the target device.



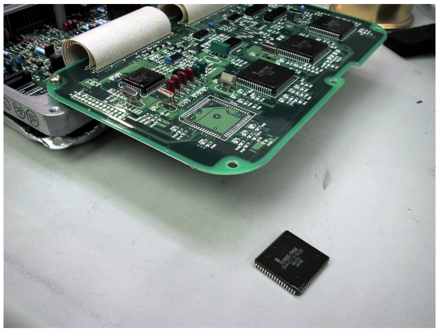
Step 1
Apply pre-heat from back side of the target device. Keep applying heat until you can't touch the chip. By this time, circuit board should have enough heat.



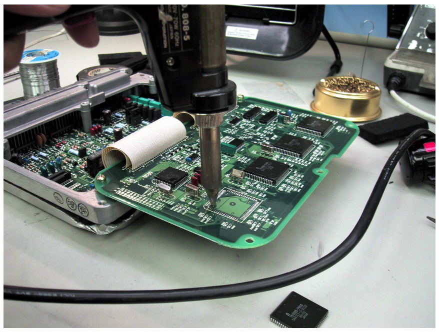
Step 2
Apply heat from top of the target device. Nozzle should cover entire chip. You can check if chip is free from solder by sliding the nozzle left and right. Make sure you don't move other parts. If the chip moves freely, it is ready to be removed.



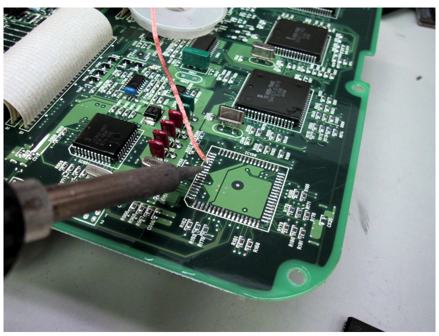
Step 3
Remove the chip straight up to avoid making solder bridge between pins. Chip is extremely hot! Unless you have skin of steel, avoid imitating the picture.



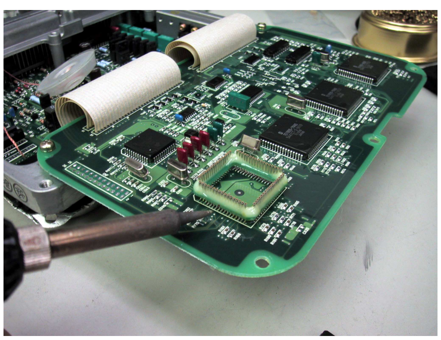
Step 4
After remove the chip, cool down both circuit board and chip.



Step 5
Clean the pads on the circuit board with desoldering gun.
Do not apply too much heat to the pad. Pad might peel off from circuit board. Clean the chip by desoldering gun also.
Check for any bridge between pins. If the chip has too much protective coating on it, use solvent to clean it up.



Step 6
If the pads on the circuit board is too small to use desolding gun, try cleaning by solder wick with rosin flux. This may take time but it is much better than peeling pads off.
Once again, do not apply too much heat.



Step 7
Solder the RomBoard adapter where the chip was.
Refer SMD device soldering section for how to solder adapter.

The Final Word

Soldering, desoldering, and working with SMD device will take some effort to learn. You should be relaxed and concentrated when you work.
Keeping every thing clean (tip of iron, gun, work surface, etc) will help you also.
Once you get comfortable to work with soldering you may find your own tips and tricks.
Experience is all bout soldering.

EOF

How To Solder - Soldering Tutorial

Soldering is defined as "the joining of metals by a fusion of alloys which have relatively low melting points". In other words, you use a metal that has a low melting point to adhere the surfaces to be soldered together. Consider that soldering is more like gluing with molten metal, unlike welding where the base metals are actually melted and combined. Soldering is also a must have skill for all sorts of electrical and electronics work. It is also a skill that must be taught correctly and developed with practice. This tutorial will cover the most common types of soldering required for electronics work. This includes soldering components to printed circuit boards and soldering a spliced wire joint. This presentation came from http://www.aaroncake.net/electronics/solder.htm

Soldering Equipment

The Soldering Iron/Gun

The first thing you will need is a soldering iron, which is the heat source used to melt solder. Irons of the 15W to 30W range are good for most electronics/printed circuit board work. Anything higher in wattage and you risk damaging either the component or the board. If you intend to solder heavy components and thick wire, then you will want to invest in an iron of higher wattage (40W and above) or one of the large soldering guns. The main difference between an iron and a gun is that an iron is pencil shaped and designed with a pinpoint heat source for precise work, while a gun is in a familiar gun shape with a large high wattage tip heated by flowing electrical current directly through it.

A 30W Watt Soldering Iron

A 300W Soldering Gun

For **hobbyist electronics** use, a soldering iron is generally the tool of choice as its small tip and low heat capacity is suited for printed circuit board work (such as assembling kits). A soldering gun is generally used in heavy duty soldering such as joining heavy gauge wires, soldering brackets to a chassis or stained glass work.

You should choose a soldering iron with a 3-pronged grounding plug. The ground will help prevent stray voltage from collecting at the soldering tip and potentially damaging sensitive (such as CMOS) components. By their nature, soldering guns are quite "dirty" in this respect as the heat is generated by shorting a current (often AC) through the tip made of formed wire. Guns will have much less use in hobbyist electronics so if you have only one tool choice, an iron is what you want. For a beginner, a 15W to 30W range is the best but be aware that at the 15W end of that range, you may not have enough power to join wires or larger components. As your skill increases, a 40W iron is an excellent choice as it has the capacity for slightly larger jobs and makes joints very quickly. Be aware that it is often best

to use a more powerful iron so that you don't need to spend a lot of time heating the joint, which can damage components.

A variation of the basic gun or iron is the soldering station, where the soldering instrument is attached to a variable power supply. A soldering station can precisely control the temperature of the soldering tip unlike a standard gun or iron where the tip temperature will increase when idle and decrease when applying heat to a joint. However, the price of a soldering station is often ten to one hundred times the cost of a basic iron and thus really isn't an option for the hobby market. But if you plan to do very precise work, such as surface mount, or spend 8 hours a day behind a soldering iron, then you should consider a soldering station.

The rest of this document will assume that you are using a soldering iron as that is what the majority of electronics work requires. The techniques for using a soldering gun are basically the same with the only difference being that heat is only generated when the trigger is pressed.

Solder

The choice of solder is also important. There several kinds of solder available but only a few are suitable for electronics work. Most importantly, you will only use *rosin core solder*. *Acid* core solder is common in hardware stores and home improvement stores, but meant for soldering copper plumbing pipes and not **electronic circuits**. If acid core solder is used on electronics, the acid will destroy the traces on the printed circuit board and erode the component leads. It can also form a conductive layer leading to shorts.

For most printed circuit board work, a solder with a diameter of 0.75MM to 1.0MM is desirable. Thicker solder may be used and will allow you to solder larger joints more quickly, but will make soldering small joints difficult and increase the likelihood of creating solder bridges between closely spaced PCB pads. An alloy of 60/40 (60% tin, 40% lead) is used for most electronics work. These days, several lead-free solders are available as well. **Kester "44" Rosin Core** solder has been a staple of electronics for many years and continues to be available. It is available in several diameters and has a non-corrosive flux.

Large joints, such as soldering a bracket to a chassis using a high wattage soldering gun, will require a separate application of brush on flux and a thick diameter solder of several millimeters. Remember that when soldering, the flux in the solder will release fumes as it is heated. These fumes are harmful to your eyes and lungs. Therefore, always work in a well-ventilated area and avoid breathing the smoke created. Hot solder is also dangerous. It is surprisingly easy to splash hot solder onto yourself, which is a thoroughly unpleasant experience. Eye protection is also advised.

Preparing To Solder

Tinning the Soldering Tip

Before use, a new soldering tip, or one that is very dirty, must be tinned. "Tinning" is the process of coating a soldering tip with a thin coat of solder. This aids in heat transfer between the tip and the component you are soldering, and also gives the solder a base from which to flow from.

Step 1: Warm Up the Iron

Warm up the soldering iron or gun thoroughly. Make sure that it has fully come to temperature because you are about to melt a lot of solder on it. This is especially important if the iron is new because it may have been packed with some kind of coating to prevent corrosion.

Step 2: Prepare A Little Space

While the soldering iron is warming up, prepare a little space to work. Moisten a little sponge and place it in the base of your soldering iron stand or in a dish close by. Lay down a piece of cardboard in case you drip solder (you probably will) and make sure you have room to work comfortably.

Step 3: Thoroughly Coat the Tip in Solder

Thoroughly coat the soldering tip in solder. It is very important to cover the entire tip. You will use a considerable amount of solder during this process and it will drip, so be ready. If you leave any part of the tip uncovered it will tend to collect flux residue and will not conduct heat very well, so run the solder up and down the tip and completely around it to totally cover it in molten solder.

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Step 4: Clean the Soldering Tip

After you are certain that the tip is totally coated in solder, wipe the tip off on the wet sponge to remove all the flux residue. Do this immediately so there is no time for the flux to dry out and solidify.

Step 5: You're Done!

You have just tinned your soldering tip. This must be done anytime you replace the tip or clean it so that the iron maintains good heat transfer.

Soldering a Printed Circuit Board (PCB)

Soldering a PCB is probably the most common soldering task an electronics hobbyist will perform. The basic techniques are fairly easy to grasp but it is a skill that will take a little practice to master. The best way to practice is to buy a simple electronics kit or assemble a simple circuit (such as an **LED chaser**) on a perf-board. Don't buy that expensive kit or dive into a huge project after only soldering a few joints.

Soldering components onto a PCB involves preparing the surface, placing the components, and then soldering the joint.

Step 1: Surface Preparation:

A clean surface is very important if you want a strong, low resistance solder joint. All surfaces to be soldered should be cleaned well. **3M Scotch Brite pads** purchased from the home improvement, industrial supply store or automotive body shop are a good choice as they will quickly remove surface tarnish but will not abrade the PCB material. Note that you will want *industrial* pads and not the kitchen cleaning pads impregnated with cleaner/soap. If you have particularly tough deposits on your board, then a fine grade of steel wool is acceptable but be very cautious on boards with tight tolerances as the fine steel shavings can lodge between pads and in holes.

Once you have cleaned the board down to shiny copper you can use a solvent such as acetone to clean any bits of the cleaning pad that may remain and to remove chemical contamination from the surface of the board. Methyl hydrate is another good solvent and a bit less stinky then acetone. Be aware that both these solvents can remove ink, so if your board is silk screened, test the chemicals first before hosing down the entire board.

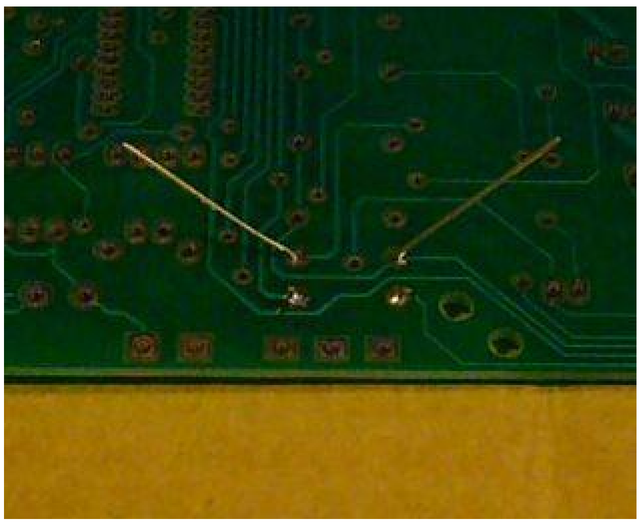
A few blasts with compressed air will dry out the board and remove any junk that may have built up in the holes.

Step 2: Component Placement

After the component and board have been cleaned, you are ready to place the components onto the board. Unless your circuit is simple and only contains a few components, you will probably not be placing all the components onto the board and soldering them at once. Most likely you will be soldering a few components at a time before turning the board over and placing more. In general it is best to start with the smallest and flattest components (resistors, ICs, signal diodes, etc.) and then work up to the larger components (capacitors, power transistors, transformers) after the small parts are done. This keeps the board relatively flat, making it more stable during soldering. It is also best to save sensitive components (MOSFETs, non-socketed ICs) until the end to lessen the chance of damaging them during assembly of the rest of the circuit.

Bend the leads as necessary and insert the component through the proper holes on the board. To hold the part in place while you are soldering, you may want to bend the leads on the bottom of the board at a 45 degree angle. This works well for parts with long leads such as resistors. Components with short leads such as IC sockets can be held in place with a little masking tape or you can bend the leads down to clamp onto the PC board pads.

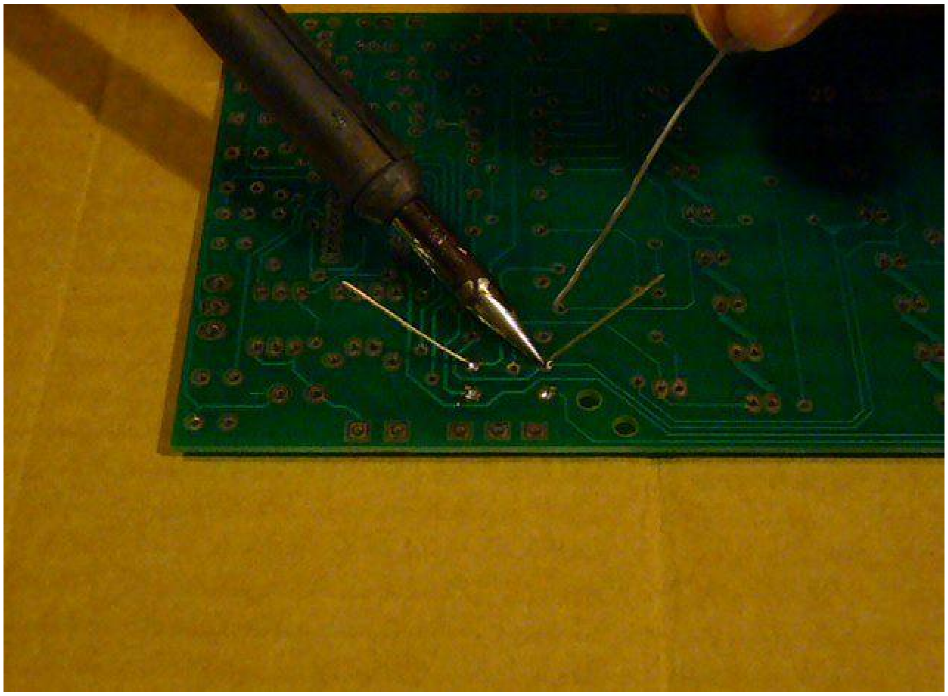
In the image below, a resistor is ready to solder and is held in place by slightly bent leads.



Step 3: Apply Heat

Apply a very small amount of solder to the tip of the iron. This helps conduct the heat to the component and board, but it is **not** the solder that will make up the joint. To heat the joint you will lay the tip of the iron so that it rests against both the *component lead* and the *board*. It is critical that you heat the lead and the board, otherwise the solder will simply pool and refuse to stick to the unheated item. The small amount of solder you applied to the tip before heating the joint will help make contact between the board and the lead. It normally takes a second or two to get the joint hot enough to solder, but larger components and thicker pads/traces will absorb more heat and can increase this time.

If you see the area under the pad starting to bubble, **stop** heating and remove the soldering iron because you are overheating the pad and it is in danger of lifting. Let it cool, then carefully heat it again for much less time.



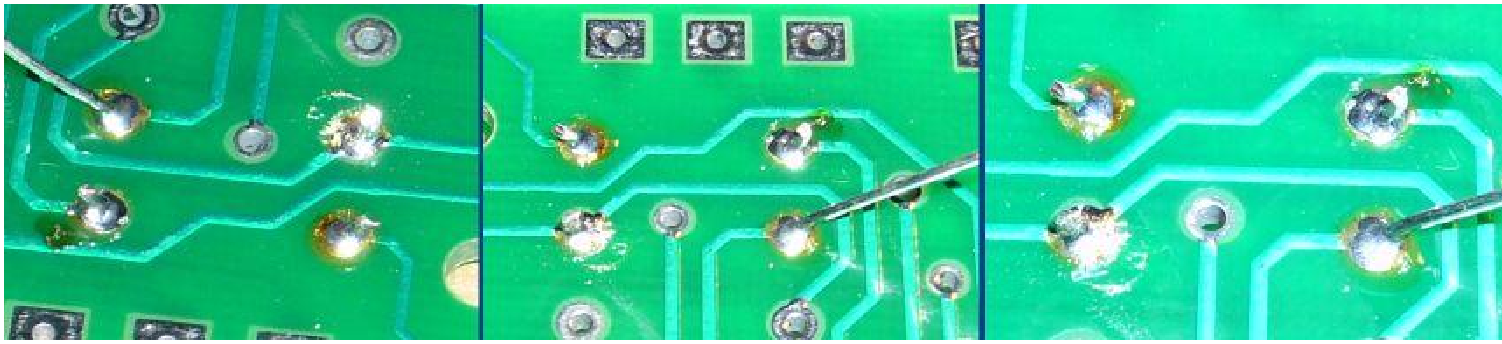
Step 4: Apply Solder to the Joint

Once the component lead and solder pad has heated up, you are ready to apply solder. Touch the tip of the strand of solder to the component lead and solder pad, but **not** the tip of the iron. If everything is hot enough, the solder should flow freely around the lead and pad. You will see the flux melt liquefy as well, bubble around the joint (this is part of its cleaning action), flow out and release smoke. Continue to add solder to the joint until the pad is completely coated and the solder forms a small mound with slightly concave sides. If it starts to ball up, you have used too much solder or the pad on the board is not hot enough.

Once the surface of the pad is completely coated, you can stop adding solder and remove the soldering iron (in that order). Don't move the joint for a few seconds as the solder needs time to cool and solidify. If you do move the joint, you will get what's called a "cold joint". This is recognized by it's characteristic dull and grainy appearance. Many cold joints can be fixed by reheating and applying a small amount of solder, then being allowed to cool without being disturbed.

Step 5: Inspect the Joint and Cleanup

Once the joint is made you should inspect it. Check for cold joints (described a little above and at length below), shorts with adjacent pads or poor flow. If the joint checks out, move on to the next. To trim the lead, use a small set of side cutters and cut at the top of the solder joint.



After you have made all the solder joints, it is good practice to clean all the excess flux residue from the board. Some fluxes are hydroscopic (they absorb water) and can slowly absorb enough water to become slightly conductive. This can be a significant issue in a hostile environment such as an automotive application. Most fluxes will clean up easily using methyl hydrate and a rag but some will require a stronger solvent. Use the appropriate solvent to remove the flux, then blow the board dry with compressed air.

Cold Solder Joints

A "cold solder joint" can occur when not enough heat is applied to the component, board, or both. Another common cause is a component moving before the solder has completely cooled and solidified. A cold joint is brittle and prone to physical failure. It is also generally a very high resistance connection which can affect the operation of the circuit or cause it to fail completely.

Cold joints can often be recognized by a characteristic grainy, dull gray color, but this is not always the case. A cold joint can often appear as a ball of solder sitting on the pad and surrounding the component lead. Additionally you may notice cracks in the solder and the joint may even move. Below is the shocking image of every example of a bad solder joint you will ever see. It appears that this **FM transmitter kit** was assembled using the technique of "apply solder to iron then drip onto joint". If your joints are looking like this, then **stop** and practice after rereading this page. Note that not a single of of these joints is acceptable, but amazingly, the circuit worked.

Most cold solder joints can be easily fixed. Generally all that is required is to reheat the joint and apply a little more solder. If there is already too much solder on the joint, then the joint will have to be **desoldered** and then soldered again. This is done by first removing the old solder with a desoldering tool or simply by heating it up and flicking it off with the iron. Once the old solder is off, you can resolder the joint, making sure to heat it thoroughly and keep it still as it cools.